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Work Plan for the Delineation of Mercury in Soil at the Building 212 Facility Lawrence Livermore National Laboratory

May 2010

Environmental Restoration Department

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1. Introduction

1.1. Purpose

This work plan describes the activities to determine the lateral and vertical extent of elemental mercury in accessible areas near Building 212 at the Lawrence Livermore National Laboratory (LLNL), Livermore Site, which was discovered during building demolition activities in 2008. This work will be executed by the LLNL Environmental Restoration Department (ERD) for the U.S. Department of Energy (DOE) in accordance with the existing plans and procedures developed for LLNL's ongoing Livermore site cleanup under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

1.2. Project Objectives

The objectives of this project are to define the lateral and vertical extent of mercury in the unsaturated zone while minimizing waste generation and the spread of mercury. Radionuclides that are co-located with mercury will be characterized to determine the disposition of any soil waste that is generated during the project. However, defining the full extent of any radionuclides present in the Building 212 area and their isotopic speciation is beyond the scope of this work plan.

Once approved and implemented, the analytic data acquired under this work plan will allow DOE and LLNL to prepare a cost estimate for completing the removal of mercury from the Building 212 area. This work plan was reviewed by the U.S. Environmental Protection Agency (EPA), California Department of Toxic Substances Control (DTSC), and San Francisco Bay Regional Water Quality Control Board (RWQCB).

1.3. Scope of Work

Free-phase mercury was identified in soil during demolition of Building 212. Removal of some soil containing mercury was performed by LLNL in 2008. However confirmation sampling indicated that mercury remains in subsurface soil, and the extent of mercury is not known.

This work plan proposes a phased, "step-out" approach to define the lateral and vertical extent of mercury in soil. The first phase will consist of: 1) discrete-depth soil sampling to a depth of 5 ft, and 2) a surface soil gas walkover survey using real-time onsite field analytical techniques. Based on the first phase findings, the second phase will consist of vertical and horizontal "step-out" soil sampling to define the extent of mercury, where accessible.

1.4. Data Quality Objectives

The EPA's Data Quality Objectives (DQOs) Process is a series of seven logical steps that guides planners to the resource-effective acquisition of environmental data. The DQO process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO process leads to efficient and effective expenditure of resources; consensus on the

type, quality, and quantity of data needed to meet the project goals; and appropriate documentation of actions taken during the development of the project. The ERD conducts its work projects in accordance with the approved Quality Assurance Project Plan (QAPP) (Dibley, 1999) requirements for planning, performing, documenting, and verifying the quality of activities and data. The QAPP was prepared for CERCLA compliance and ensures that the precision, accuracy, completeness, and representativeness of project data are known and are of acceptable quality. The QAPP is used in conjunction with the LLNL ERD Standard Operating Procedures (SOPs), Work Plans, Integration Work Sheets (IWSs), Site Safety Plans, and any other applicable ES&H and/or QA regulatory requirements. Additionally, for the investigations described in this work plan, the EPA guidance *Systematic Planning Using the DQO Process* (EPA, 2006) was followed. Table 1 summarizes the specific DQO steps for the Building 212 mercury investigation.

2. Site History and Description

2.1. Site Location and Use

LLNL is in the process of demolishing Building 212 at the Livermore Site. The building is located on the south perimeter of LLNL along East Avenue (Figure 1). The building was constructed in the mid-1940s and was in continuous use by the Naval Air Station (NAS) Livermore and LLNL until the mid-1980s. The summary of building activities below was taken from the *Historic Context and Building Assessments for the Lawrence Livermore National Laboratory Built Environment* (LLNL, September 2007).

Building 212 was originally constructed in 1943 as a Drill Hall for NAS Livermore. In 1952, the Drill Hall was renovated for the fusion research program, Project Sherwood. In 1954, the Drill Hall underwent major structural renovations when a 90-inch cyclotron and a 0.5 Mega electron Volt (MeV) Cockcroft-Walton accelerator were installed. Each of these machines required a forty-foot deep pit and blockhouse. In 1964, a 630-ft concrete addition to the east end of the building to accommodate the new Crockcroft-Walton accelerator was completed. In 1968, a 90-inch cyclotron was removed and a 80-centimeter cyclotron and Van de Graaf accelerator were installed. It is believed that mercury-sealed vacuum pumps were serviced in a machine shop on the north side of Building 212 (Figure 2). During the 1970s and 1980s, Building 212 continued to be modified to accommodate various research programs such as the Rotating Target Neutron Source, the Two Stage Light Gas Gun, the Flash Light Source Facility, the High-Energy X-ray Calibration Spectrometer, the Electron Beam Ion Trap, the Vacuum Coating Facility, and the Phase R Dye laser.

Surrounding buildings north of Building 212, Building 211 and Building 218 were primarily used for office space (Figure 3). Building 2127, an old barracks, has always been used as office space. However from 1967 to 1975, Building 211 contained a machine shop on the south side of the building, which contained a mercury reclaimer (as referenced in Figure 4.1-2 and Table 4.1-2 from LLNL, 1990, and Table B-1 from LLNL, 1985).

2.2. Geology and Hydrogeology

The Building 212 area is underlain by Quaternary-age alluvial fan deposits consisting primarily of sandy silt, clayey silt, and silty sand with occasional interbeds of sandy gravel and gravelly sand. Depth-to-water in the area is currently about 92 ft below ground surface (bgs)and the ground water flow direction is generally to the west. Hydrostratigraphic unit 2 (HSU 2), extending from 88 to 160 ft bgs is the first saturated HSU in the area and contains low concentrations of volatile organic compounds, including trichloroethylene (TCE), carbon tetrachloride (CTET), chloroform, and Freon 113. TCE and CTET are at or slightly below their respective MCLs. This dilute plume is currently being hydraulically contained and treated at Treatment Facility G - 1 (TFG-1) located about 200 ft north of the study area. The Building 212 area is not considered to be the source of these VOCs, which are thought to have been derived from areas to the east.

2.3. Previous Investigations

In the vicinity of Building 212, several borings and monitoring wells have been installed to characterize soil and ground water contamination (Figure 3). A total of 28 borings were drilled and five wells/piezometers were installed between 1984 and 2009. The total depth investigated was 262 ft bgs. The timeline of Building 212 borehole drilling and well/piezometer installation is below:

- 1984: five borings, C-212-1 through C-212-5 were drilled and one monitoring well, W-111, was installed (Figure 3). These borings ranged in depth from 11 ft bgs to 117 ft bgs.
- 1988 through 1989: six borings (B-464, B-560, SIB-212-001, -002, -003, and -004) and two monitoring wells (W-464 and W-560) were drilled to depths ranging from 91.3 to 262.7 ft bgs (Figure 3).
- 1996 through 1997: three wells/piezometers were installed: SIP-212-101, TW-11, and TW-11A (Figure 3).
- 1994 through 2007: seven shallow pre-construction borings, (PC-B212-012, -013, -014, -015, -016, -017 and -018) were drilled between the surface and 4 ft bgs (Figure 3).
- 2009: ten shallow pre-construction borings (PC-B212-019, PC-B212-020, PC-B212-021, PC-B212-022, PC-B212-023, PC-B212-024, PC-B212-025, PC-B212-026, PC-B212-027 and PC-B212-028) were drilled between the surface and 3 ft bgs.

Samples from the borings and monitoring wells were analyzed for various analytes including the contaminants of concern for this investigation: mercury, gross alpha, gross beta and tritium. Table 2 summarizes the analyses conducted between 1984 and 2009. Based on the historical data, mercury was not detected in soil samples from boring B-464, B-560 or SIB-212-101 (Table 3). However, mercury was detected in PC-212 borings completed between 1997 and 2009 (Table 4). Mercury was detected in six samples at low concentrations ranging from 0.03 milligrams per kilogram (mg/kg) up to 0.21 mg/kg. These concentrations are all below the EPA screening level of 4.3 mg/kg for residential land use. Gross alpha and gross beta were detected during previous investigations but at low levels: gross alpha up to 10 picocuries per gram (pCi/g) and gross beta up to 23 pCi/g (Tables 3 and 4).

Mercury was not detected in 14 of the 15 water samples collected between 1983 and 1996 in wells TW-11, T-11A and W-560, which are upgradient of Building 212, and in well W-464, which is located downgradient of the Building 212 Area (Table 5). Mercury was detected in well W-464 in 1989 at 0.0003 mg/L, but was not detected in two sampling events in 1990 and 1995 (Table 5). Tritium was detected in five wells, SIP-212-101, TW-11, TW-11A, W-111, and W-464. Two wells TW-11 and TW-11A, are upgradient of Building 212, well SIP-212-101 is on the south side of Building 212, well W-111 is directly downgradient of Building 212, and well W-464 is downgradient to the north of Building 212 (Figure 3). Tritium was detected at activities up to 2,000 picocuries per Liter (pCi/L), with the highest activities in well W-464 (Table 5). Gross alpha was detected in 1996 in wells TW-11, W-111, and W-464 at activities up to 10.6 pCi/L. Gross beta was detected in 1984 in well TW-11A at 8 pCi/L, but was not detected in TW-11A in 1996. Gross beta was detected in 1996 in well TW-11 at 7.6 pCi/L. Tritium was detected in the soil in the vicinity of Building 212, but the activities detected in ground water do not indicate that there is a ground water source of tritium in the vicinity of Building 212.

2.4. Recent Site Activities

LLNL began demolition of Building 212 in April 2008. Two of the demolition activities included cutting and capping (C&C) or cutting and plugging (C&P) the Building sanitary sewer lines that connected to main sanitary sewer lines (Figure 4) and sampling and analyzing all the sink sediment traps. The results for the sink sediment traps were non-detect. During the demolition activities free mercury was encountered in a low spot in a sink drain line along the south side of the building in Room 160 (Figure 4).

On April 16, 2008, demolition staff discovered several small beads of mercury on the concrete foundation on the north side of the building Figure 4 and Figure 5. LLNL staff responded and cleaned up this mercury and managed it as hazardous waste. On April 17, 2008, additional small beads of mercury were discovered in soil adjacent to the foundation. The extent of visible mercury in the soil was small, and LLNL developed and implemented a plan to clean up the affected area. However, after a shovel of soil approximately one-inch deep was removed, a larger amount of mercury was discovered, at which point clean-up actions were halted to further evaluate the situation.

Visually-verifiable contamination was in an area approximately 18 inches wide by 24 inches long to an unknown depth. The area was bound on the north by a pedestrian sidewalk and on the south by the Building 212 concrete foundation (Figures 5 and 6). Because the mercury was beneath the surface, it was impossible to determine the extent of contamination without subsurface investigation. Therefore, LLNL prepared a time-critical removal action plan (LLNL, 2008) to further investigate the extent of the mercury in soil. To be conservative, soil was excavated 25 ft horizontally and to a depth of 3 ft along the north side of the building in the vicinity of the observed beads of mercury (Figure 7). Based on the analytical data, the horizontal extent of the mercury exceeds the 25-foot removal area and the vertical extent of the mercury exceeds 3-ft in depth. In addition, utilities were encountered at the 3-foot depth (LLNL, 2009).

The confirmation sample data (Figure 7) indicated that the extent of mercury was not fully bound vertically or laterally (Table 6). Mercury was above total threshold limit concentration (TTLC) in the samples collected from the north sidewall, east sidewall and the bottom of the excavation on the eastern end (Figure 7).

Gross alpha and gross beta activities in samples collected from the bottom of the excavation during the initial mercury removal action ranged from 8.95 pCi/g to 11.1 pCi/g and 17.2 pCi/g to 19.9 pCi/g, respectively (Table 6). Isotopic data for this soil (Table 7) indicate that the suite of isotopes present and their activities are generally consistent with typical isotopic background activities encountered in the Coast Range Province of California (Devany, 2009). Site-specific isotopic background values, however, are not currently available for the Livermore site.

A chronology of the Building 212 demolition activities is summarized in Table 8.

The topography in the area gently slopes to the west, therefore storm drains downgradient of the site to the west were checked in December 2009 (Figure 4). The inspection consisted of looking to see if there was any sediment which could be collected and analyzed for mercury. During the inspection, no sediment was found. LLNL has an industrial storm water permit #95174 which requires sampling storm water upstream and downstream of LLNL, therefore, water is not sampled from individual storm drains at LLNL. Data was reviewed from 1991 through 2009 for mercury detections from storm water runoff samples from two offsite discharge locations, ASS2 and ASW, identified as downgradient from Building 212 (Figure 1). Mercury has not been detected in storm water runoff from location ASS2 in the 18 year period (Table 9). Mercury was detected in storm water runoff at 0.0039 mg/L in November 1997 and at 0.0002 mg/L in November 2002 from location ASW. Mercury has not been detected in storm water runoff from ASW for the last 7 years (Table 9).

During the review of historical data, it was determined that some of the wells that were sampled in the past in the vicinity of Building 212 should be sampled again and analyzed for mercury and gross alpha and gross beta. Therefore in December 2009, the following wells were sampled, W-111, W-464, SIP-212-101, TW-11 and TW-11A. As shown on Table 5 the recent sampling results for all the wells are consistent with historical data.

2.5. Conceptual Release Model

The preliminary conceptual release model for mercury in the Building 212 area described below.

- In the 1970s -1980s, machine shop operations in Room 151 (Figure 4) on the north side of the building included a walk-in spray booth with a large exhaust vent and stack (Figure 2). It is possible that cleaning and refurbishing mercury-bearing vacuum pumps occurred either within or near the spray booth, and mercury vapors were captured by the exhaust system.
- Condensed elemental mercury was likely released along the north side of the building beneath the exhaust vent over time during the 1970s-1980s and may likely have been released along the north side of the building during building demolition activities in 2008 (Figure 2).
- Mercury vapors were likely discharged to air from the exhaust stack and vent, and transported by prevailing winds prior to condensing on the ground, roads sidewalks, buildings and vegetation.
- Root-holes and other macropores in soil near the release areas possibly allowed elemental mercury to move vertically and laterally in soil near the exhaust vent and in downwind locations.

- Stormwater containing mercury-bearing sediment from the release area may have dispersed mercury in local drainage features (stormdrains, swales, ditches, low points).
- Permeable backfill for utility conduits along the north side of the building may have acted as pathways for elemental mercury, mercury vapors and/or mercury-laden sediment to move away from the release area (Figure 4).

2.6. Investigation Areas

Based on the recent building demolition activities, the following areas have been identified to investigate the lateral and vertical extent of mercury (Figure 8).

Area 1 – The general area within the footprint of the north side of the building and the landscaped area and sidewalk adjacent to Rooms 145, 151 and 167, including the previously trenched area (Figure 4). Rooms 145 and 151 were machine shops, and Room 167 was a boiler room. A walk-in spray booth was present in the east corner of Room 151. Exhaust from the booth was vented to the outside in the vicinity of where the mercury beads were found on the concrete foundation during the Building 212 demolition activities.

Area 2 – This area includes: 1) the landscaped area, sidewalk, and street gutter along the north side of the building east and west of Area 1 where mercury may have been transported by wind and stormwater runoff, respectively (Figure 4); 2) the area within South Mall Street where mercury may have migrated laterally in permeable backfill surrounding underground utilities; and 3) the north side of South Mall Street in the vicinity of Building 211 which had a mercury reclaimer in the machine shop in the south side of the building which operated from 1967 to 1975.

Area 3 – The parking lot on east side of Building 212 in the vicinity of Building 2128. This building has been removed and its chemical usage is unknown.

Area 4 – The landscaped area adjacent to the foundation on the south side of the building near the lab sink rooms, Rooms 154, 160, 162 and 170. Room 160 is where the copper pipe containing mercury was discovered (Figure 4).

3. Sampling

Because the full extent of the mercury-impacted area is not known, a real-time sampling and analysis approach has been developed. This involves collecting depth-discrete soil samples in areas of known or suspected contamination, analyzing them on-site, and "stepping out" to additional locations and/or sampling deeper, if necessary. Ground surface air monitoring and sampling will also be used to identify potential hotspots and areas where additional soil sampling will be conducted. The Ohio Lumex mercury analyzer (RA-915+), a portable, high-sensitivity atomic absorption spectrometer will be used to monitor ambient air and analyze soil in the four investigation areas. Soil samples will be analyzed on-site using the Ohio Lumex RA-915+ with soil attachment RP-91C. The standard operating temperature range of the instrument is from 32^0 F to 122^0 F. The Ohio Lumex standard operating procedure (SOP) for using the mercury analyzer will be followed in the field. This Ohio Lumex device (RA-915+/RP-91C) was evaluated in 2004 by the EPA SITE program (EPA, 2004). This evaluation indicated that the older Lumex system could achieve minimum detection limits between 0.0053 and 0.042 mg/kg

(EPA, 2004) and could achieve a reasonable throughput of 59 samples in an 8-hr day. All instrumentation used to perform critical measurements for ERD work activities shall be used in accordance with ERD SOP 4.8: Calibration/Verification and Maintenance of Measuring and Test Equipment (M&TE).

Duplicate mercury samples will be shipped to a National Environmental Laboratory Accreditation Program (NELAP) contracted analytical laboratory (CAL), that participates in the Department of Energy Consolidated Auditing Program (DOECAP) licensed to receive and manage potentially radioactive material. Analyses will be performed by a NELAP certification for the state of CA using the methods and procedures specified in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846, EPA, 1986 [and updates]). The applicable SW-846 method for mercury is EPA Method 7471. The applicable lab-specific SOPs will be selected for the radionuclide analyses. All analytical tests performed shall be available as part of the contract analytical bid package spread sheet, which specifies the requested analysis code, analytical method, analyte(s), parameter code, CAS number, sample matrix, and reporting limit.

3.1. Sampling Methodology

The proposed sampling methodology consists of 1) a depth-discrete soil sampling plan in the vicinity of Building 212; and 2) a surface soil gas walk-over survey in all four areas. Since the volatility of mercury vapor is temperature-dependent, it would be prudent to conduct the survey under warmer conditions. Based on the current conceptual release model, mercury was likely concentrated in shallow soil beneath the former exhaust vent and a significant portion of the release was removed in 2008. However, it is not clear to what extent wind, storm water runoff, root-holes, macropores and permeable backfill surrounding underground utilities may have transported the mercury vertically and horizontally from the release area. Therefore, a real-time sampling and analysis approach will be used to expeditiously determine the vertical and lateral extent of the remaining mercury. In areas where mercury is known or suspected to be present based on prior investigations and removal actions, depth-discrete soil sampling will be conducted to determine the vertical extent of the mercury. In areas of potential wind and/or storm water runoff deposition, a walk-over survey will be conducted to determine if mercury vapor is present in air immediately above surface grade. Where mercury air concentrations above ambient are present at the surface, depth-discrete sampling will be conducted to determine the vertical extent of the mercury.

In compliance with Integration Worksheet (IWS) 12654, *Drilling in VOC and Mixed Waste-contaminated Soils at the Livermore Site, and Draft SOP 1.3: Drilling,* the Drilling Coordinator should verify that underground utilities have been surveyed and necessary permits have been issued including National Environmental Policy Act (NEPA), wildlife, and archaeological surveys required by the PROC-CON-003 Soil Excavation and Permit process. This preparatory work is accomplished prior to drilling into concrete or soil, to ensure that sampling locations avoid subsurface utility corridors. The work surface at each boring will be covered with poly sheeting to minimize the spread of contamination. The soil generated during this investigation will be segregated on plastic at 1-ft intervals in the same order it was removed and placed back in the borehole (i.e., soil from the 4-5 ft interval will be placed at the bottom of the hole, soil generated from the 3-4 ft interval will be placed on top of the 4-5 ft interval, etc.) and tamped into place. Due to the removal of soil for sampling and analysis if there is insufficient soil to

completely fill the borehole, then hydrated bentonite chips will be used to do so. If additional deeper depth-discrete sampling is required in such a boring, then it will be sealed only with bentonite chips. If the boring is completed and additional sampling is not required then the top six inches will be backfilled with grout. If there is excess soil, it will be placed in a 55-gallon drum. If field logistics prohibit placing cuttings back in the hole, it will be placed in a 55-gallon drum for offsite disposal and the boring will be backfilled with grout.

3.1.1. Depth-Discrete Soil Sampling

Depth-discrete soil sampling will be conducted as shown in Figure 8 in investigation Area 1 and parts of investigation Area 2, and in any additional areas where the walk-over survey and subsequent sampling showed mercury concentrations above the SL. Investigation Areas 1 and 2 have several different utilities in or nearby them; therefore, depth-discrete soil sampling will be conducted initially by hand-augering.

A sampling approach has been developed to efficiently and effectively delineate the extent of mercury. The approach is detailed in a flow chart presented on Figure 9. The sampling approach consists of four different sampling scenarios as shown on Figures 8 and 9:

- Scenario 1: Surface sampling in areas where there is a high likelihood that mercury was transported via stormwater runoff or wind;
- Scenario 2: Sampling at 1, 3 and 5 ft bgs at locations where mercury may have been transported via root holes, macropores, and/or utility conduits;
- Scenario 3: Sampling at 5 ft bgs at locations where mercury was encountered at 3 ft during the removal action (which was backfilled with clean fill) but due to work scope limitations was not investigated at greater depth;
- Scenario 4: Step-out sampling at locations and depths determined by the mercury results from either the walk-over survey or Scenarios 1 through 3, potentially 1, 3 and 5 ft bgs or deeper, where mercury may have been transported via root holes, macropores, and/or utility conduits.

Using a hand auger, borings will be advanced to the specified sampling depths identified per the sampling scenario for a given location (Figure 8). At each depth, cuttings from the soil boring for the sampling interval will be collected, placed in a heavy-duty plastic bag, which will then be sealed and fully homogenized by squeezing and shaking the bag. Using the RA-915+ mercury analyzer, a screening reading of the soil vapor will be measured in the bag and recorded. Approximately 200 milligrams (mg) of soil will then be removed from the bag and analyzed on-site using the RA-915+ and RP-91C. The soil result will be recorded and to verify the soil result, two more soil analyses will be conducted on soil from the bag. An average of the soil results will be calculated and compared to the 5.6 mg/kg SL for elemental mercury.

In Scenario 1, if the surface soil result is above the SL then additional samples will be collected at 2 ft depth intervals until the results are below the SL. In scenarios 2 and 3, if the 5 ft depth sample is above the SL, then a direct push rig with dual tube technology to minimize vertical cross-contamination will be mobilized to collect additional samples at subsequent 2 ft depth intervals (i.e., 7, 9, 11 ft, etc.) until the results are below the SL.

If any analytical results in Scenarios 1 through 3 are above the SL, then Scenario 4 will be triggered and additional step-out borings will be hand-augered and sampled at the depths where the mercury results exceeded the SL in the initial boring, potentially at the surface, or 1, 3 and 5 ft and deeper as necessary. The "step-out" approach will consist of hand augering/drilling step-out borings 10 ft to the north, east and west (labeled as "A" in Figure 8) from the initial boring with mercury detections greater than the SL (Figure 8). If this second boring contains mercury greater than the SL, then additional step-out borings will be hand augered/drilled 10 ft to the north, east and west (labeled as "B" in Figure 8) from that second boring. This "step-out" approach will continue until results are below the SL for mercury.

If during hand-augering activities or direct push drilling, there is refusal, the boring will be backfilled as described above and a new boring will be drilled approximately 3 ft from the initial boring. If refusal is met in this boring that is not related to subsurface utilities, then this location will be investigated with other drilling methods (e.g., sonic or auger drill rig) at a later date, if necessary.

The hand-augered borings will be backfilled with soil as described above, and if additional deeper depth-discrete sampling is necessary, then the direct push rig will be set up on the same hand-augered location and will push rods down to the last sampled interval without collecting any soil. Once at that depth, the rods will be filled with acetate tubing and continuous core will be collected to the next sample interval and the process will be repeated as necessary. If the hand-augered boring was filled with grout, another boring adjacent to the hand-augered boring will be drilled. The deeper borings will be grouted once the sampling is completed.

All final step-out mercury samples (i.e., those below 5.6 mg/kg or the last sample before refusal) will be sent to an offsite contracted analytical laboratory (CAL) for confirmation. In addition on a daily basis and randomly selected at least 10% of the samples with field concentrations above 5.6 mg/kg will be submitted to an offsite CAL for confirmation analysis. In accordance with LLNL ERD SOP 4.9: Collection of Field QC Samples and to meet the ERD DQOs as defined in the QAPP for the ERD Projects, the 10% will be divided into 5% interlaboratory and 5% intralaboratory collocated samples.

For waste characterization purposes, soil samples will also be collected at the surface, and from 1, 3 and 5 ft bgs (and deeper as necessary). The deepest soil sample in a borehole where mercury exceeds the 5.6 mg/kg mercury SL will be submitted for off-site analysis of gross alpha, gross beta and tritium. For this sample interval, a 32-ounce (oz) sample volume will be collected for the radionuclide analysis. Extra soil remaining after the radionuclide analysis will be held at the CAL for future isotopic analysis, if required.

3.1.1.1. Field Analysis

Soil from each sampled interval will be analyzed in the field for mercury. The field analysis will consist of filling a bag with approximately 40 ounces of soil and mixing the soil to homogenize the sample. Approximately 200 mg of soil will be removed from the bag and analyzed on-site using the RA-915 and RP-91C. The result will be recorded and to verify the result, two more analyses will be conducted on the soil from the bag. The remaining soil will be put into an 8 oz jar and handled in accordance with preservation requirements defined in ERD SOP 4.3: Sample Containers and Preservation. The soil sample(s) will be sent to an off-site CAL for potential confirmation mercury, TTLC, STLC, and TCLP metals analyses to evaluate the

disposal options for later removal actions. If mercury is visible in the soil, then the field analysis will not be conducted, the soil will be placed in an 8 oz jar and sent to the off-site CAL for potential TTLC, STLC, and TCLP metals analyses.

3.1.1.2. Laboratory Analysis

Table 10 summarizes the sampling and analysis plan described above. The CAL for the selected soil samples for elemental mercury using EPA Method 7471 will be BC laboratories, Inc. Curtis & Tompkins, Ltd is being utilized as a QC laboratory and will receive 5% interlaboratory collocated samples for analyses. The offsite CAL for radionuclide analyses, General Engineering Laboratories (GEL) LLC will analyze selected soil samples for gross alpha and gross beta by EPA Method 900.00 modified, and tritium by EPA Method 906.0 which will be collected randomly and analyzed only for waste characterization purposes. All concentrations shall be expressed in terms of the dry sample weight. Selected samples using the LLNL waste disposal protocol detailed in ERD SOP 6.1 will be analyzed using US EPA Method 6010 for metals, STLC for metals and TCLP for metals and radionuclide speciation analysis by HASL 300. The analytical laboratories will be provided an historical range of radiological activities detected in samples collected in the area prior to performing sample analyses.

3.1.2. Surface Soil Gas Walk-over Survey

As an additional effort to identify mercury where soil sampling is not planned, a surface soil gas walk-over (survey) will be conducted. This survey will include all four investigation areas in the vicinity of the Building 212 where elemental mercury in the soil was encountered and areas where mercury may have been transported by wind and stormwater runoff (Figure 8). This survey is considered to be a screening tool and experimental in nature, however it is an important secondary means for providing information in identifying areas for additional soil sampling.

The survey will be conducted by monitoring the air with the RA-915+ mercury analyzer with the intake tube approximately one-inch off the ground. The test will only be conducted if wind speed is less than 5 miles per hour (mph) and there has been no measurable rain for a period of 10 days. The 10 day period is double the length of time recommended under the new draft Cal EPA guidance for active soil gas investigation (Cal EPA, 2010) to ensure that soil moisture levels are sufficiently low so as to not significantly impede soil gas flow to the surface. Prior to conducting the test, a daily ambient air concentration range will be established upwind of Building 212. Wind speed and direction will be collected daily from the meteorological station at LLNL (Figure 1) and the daily ambient air concentration will be collected at least 200 ft upgradient of Building 212 (Figure 1). ERD source investigation files will be reviewed to ensure that mercury was not used in the area selected for collecting daily ambient air concentration data.

Using American Society for Testing and Materials (ASTM) guidance and equations, a reporting detection limit for the mercury analyzer was calculated to determine that mercury in air could be detected if mercury in soil at 0.5 ft bgs was present at 5.6 mg/kg, which is the EPA residential screening level (SL) for elemental mercury. The calculated reporting limit is 0.0001 mg/m^3 air which is well in the range of the manufacturers specified instrument detection limit of 0.000002 mg/m^3 air. Based on the calculation, the mercury analyzer could detect mercury in air when mercury in soil is present at only 0.1 mg/kg. The calculation and the default parameters are presented in Appendix A. To evaluate the sensitivity of the meter and the ability to detect mercury during the walk-over survey, measurements will be collected in Area 1 in the

vicinity of known mercury. If mercury is detected in Area 1, the meter will be deemed acceptable for the walk-over survey and surface soil sampling will also be conducted randomly at 10% of the walk-over survey location points to confirm the walk-over survey results. If mercury is not detected in air where mercury is known to be present in soil and it is confirmed that mercury is indeed present at this location, the walk-over survey will be terminated and a plan for additional soil sampling will be developed.

In the Building 212 area, a 5 ft x 5 ft grid spacing will be used in the areas shown in Figure 8. Air readings for mercury will be collected at the center of each space and the information recorded. If the reading at any grid location is above the daily ambient air concentration range, then soil samples will be collected from a depth of six inches, 1, 3 and 5 ft bgs (Figure 10). In addition, Figure 8 presents sampling locations (brown squares) where surface samples will be collected in the areas of the walk-over survey. These sample locations were selected due to known mercury usage in the south side of Building 211 and the discovery of free mercury in a sink drain line on the south side of Building 212 (Figure 8). The soil samples will be analyzed on-site and if the result for mercury is above the EPA SL for elemental mercury (5.6 mg/kg), additional depth-discrete sampling will be conducted as described below.

3.2. Safety Procedures

Site-specific drilling and sampling procedure controls have been developed by the LLNL and are documented in the Procured-Services Work Sheet (PWS), which is attached to the Drilling IWS and will be onsite during all field activities. The controls described in the PWS and applicable IWS shall be followed during the work described in this work plan. Various methods—including direct-push and hand-augering devices may be used to obtain subsurface soil samples. The choice of method will be determined based on soil conditions, underground utilities and accessibility to sampling locations.

Both the ERD Site Safety Officer and Drilling Coordinator/Responsible Individual are responsible for making sure that all field activities are conducted in accordance with relevant Standard Operating Procedures (SOPs), and Integrated Safety Management (ISM) Integration Work Sheets (IWSs). The Drilling Geologist Supervisor is responsible for ensuring that the drilling geologist implements the drilling procedures described in this work plan.

3.2.1. Contamination Control

Based on data from the soil removal on the north side of Building 212, there may be low levels of radionuclides in soil along with the mercury. The IWS 12654, *Drilling in VOC and Mixed Waste-contaminated Soils at the Livermore Site,* will be revised to incorporate hazards associated with mercury for the Building 212 investigation.

Prior to commencing work, the LLNL Environmental Safety & Health (ES&H) Team Health Physicist will be contacted for a pre-start evaluation to ensure training and area controls are appropriate for the expected levels of contamination. An ES&H Team Technician will be notified prior to disturbing the soil and to arrange for a swipe survey of equipment before leaving the drilling site.

Only qualified personnel will conduct field activities at sites with potential tritium or other radionuclide contamination. Field personnel will have current SARA/OSHA certification and

applicable LLNL-specific training. The appropriate personal protective equipment (PPE) required when working in a mixed waste soil environment is modified level "D" protection with disposable coveralls and booties. However, due to the potential for mercury vapors, PPE will be upgraded to Level C, which includes the use of a half face respirator with mercury canisters if mercury vapors exceed the 8-Hour Time Weighted Average airborne mercury vapor exposure of 0.025 milligrams per cubic meter. Any PPE upgrades will be made by the ES&H Team Health Physicist.

If there is potential for surface contamination levels exceeding those in ES&H Manual 20.2, Appendix D, or doses approaching 100 millirem per year (mrem/yr), then disturbing radioactive contaminated soil requires use of the Health and Safety Procedure HS6300, *Contamination Control*, at a minimum, or an LLNL-trained radiation worker escort to be present during soil disturbance.

A soil contamination area must be established for areas with radioactive-contaminated soil that is not releasable in accordance with LLNL radiological environmental protection standards. Postings must include the words "Caution, Soil Contamination Area" and should include instructions or special warnings to workers, such as "Contact Hazards Control Before Digging" or "Subsurface Contamination Exists."

If contamination levels in the area exceed the values provided in ES&H Manual 20.2, Appendix D, then the area shall be posted and controlled as a contamination area or high contamination area until secured and verified less than Appendix D limits.

To control contamination, all soil cuttings will be placed on plastic sheeting next to the boring in 1 ft intervals as described in Section 3.1. These soil cuttings will be placed back in the hole once sampling is completed. However, for safety precautions, an alpha and/or beta survey meter should be used to periodically check personnel and equipment, as determined by the ES&H Team Health Physicist. Unauthorized access to the drill site will be prevented by setting up an exclusion zone. Mixed waste soil and liquids will be labeled and controlled to prevent release from the drill site. Drilling equipment will be decontaminated after leaving each investigation area following guidance provided in ERD SOP 4.5: General Equipment Decontamination.

To monitor personnel for radionuclide contamination other than tritium, an alpha and/or beta survey meter will be used to conduct a precautionary frisk of hands and feet after doffing protective clothing and prior to leaving the drill site. If contamination is detected on equipment or workers, work will stop, other workers will be alerted, and workers will be instructed to remain in the area until assisted. The ES&H Team will also be notified.

3.3. Sampling Equipment Decontamination Procedures

Decontamination shall be performed by personnel in the same level of PPE used during sampling activities.

Equipment and supplies used for equipment decontamination may include (but are not limited to) the following:

- Deionized (DI), distilled or (otherwise) analyte-free water;
- Soap and/or detergent solutions;

- Cleaning brushes;
- Chemical-free cloths or paper towels;
- Plastic buckets, galvanized steel pans; or
- Steam cleaner.

Two basic techniques employed at LLNL for removing contaminants from sampling equipment are described in SOP 4.5: General Equipment Decontamination, as follows:

a. Hand washing with a suitable detergent, e.g., "Alconox" (used when contaminant types are known or suspected, particularly when organic constituents are involved).

b. Steam cleaning (performed when equipment is too large to wash by hand).

In all cases, rinsate from decontamination activities will be collected, analyzed, and properly handled as outlined in ERD SOP 4.9: Collection of Field QC Samples.

The procedures described above are followed when the decontamination activities involve non-disposable sampling equipment used in soil sampling operations. However, to minimize waste, if the equipment can be wiped clean without the use of water, that method would be preferable. Once equipment has been cleaned, a swipe sample will be collected for onsite radionuclide analysis to clear the drill rig and other equipment prior to leaving the site.

3.4. Sample Control, Sample Tracking, and Data Control

Analytical sample custody and the analytical sample custody logbooks are to be handled and preserved as described in Appendix B.

4. Quality Assurance/Quality Control

Quality assurance (QA) is a management system for ensuring that all information, data, and decisions are technically sound and properly documented. Appendix C contains guidance for the following parameters:

- Sampling and decontamination.
- Sample custody.
- Calibration procedures and frequency.
- Analytical procedures.
- Data reduction, validation, and reporting.
- Internal quality control checks.
- Frequency, performance, and system audits.
- Specific routine procedures used to assess data precision, accuracy, and completeness.
- Corrective actions.
- QA reports to management.

Appendix C discusses QA objectives for the procedures and the data relevant to this work plan. QA considerations for procedures include field and laboratory methods. Data quality is assessed by determining the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters. Details of these procedures are presented in Appendix C.

5. Data Evaluation

Data evaluation tasks associated with the Building 212 mercury extent evaluation will include:

- Comparing metals soil results with the EPA Residential Screening Levels to determine the extent of the mercury;
- Comparing metals soil results with the Soluble Threshold Limit Concentrations (STLC) and TTLC (Table 11) for waste classification; and
- Comparing radionuclide results with the EPA Regional Screening levels to determine the extent of radionuclides and to assess the waste classification.
- ERD QC Chemists review 100% of the analytical results immediately upon receipt from the analytical laboratories. During this review, the QC Chemists verify that the analytical laboratories internal QC data is within accepatable limts, blanks are clean, dilutions, units, and reporting limits are correct. Data validation and verification is performed in accordance with SOP 4.6.
- Comparing the field results with the laboratory results.

As discussed in the Innovative Technology Verification Report Field Measurement Technology for Mercury in Soil and Sediment Ohio Lumex's RA-915+/RP-091C Mercury analyzer (EPA, 2004), the study indicated that the Ohio Lumex instrument is sensitive and comparable to the fixed laboratory and that the Ohio Lumex instrument had better precision than the fixed laboratory. However, the accuracy when comparing the Ohio Lumex field data with the fixed laboratory data did not compare well and suggests the data sets were not the same. However, in the study it was determined that the Ohio Lumex instrument provided accurate estimates for field determination. We recognize that the difference in accuracy could be due to sample heterogeneity. The soil samples will therefore be thoroughly homogenized as discussed in Section 3.1.1, however, there could still be a discrepancy in the accuracy between the fixed laboratory and the field data. If the fixed laboratory data are below the field data no further actions will be taken. If the fixed laboratory data are at least 25% higher than the field data and exceed the SL of 5.6 mg/kg, then another mobilization into the field may be necessary to collect additional soil samples.

6. Reports

As work progresses, data and interpretations will be discussed with the RPMs during routine and special meetings, as required. A report summarizing the findings will be completed once all the data have been acquired, analyzed and validated.

7. Implementation Schedule

The work plan was approved in late May and field work is tentatively schedule for June 2010. The final schedule is contingent upon weather conditions, as described in Section 3.1.2. Once the field work is completed and the data have been evaluated a summary report will be developed and is tentatively scheduled to be submitted to regulatory agencies in November 2010.

8. References

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9. Acronyms and Abbreviations

BGS	Below ground surface
BTEX	Benzene, toluene, ethylbenze and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	Chain of custody
CTET	Carbon tetrachloride
DHS	California Department of Health Services
DI	Deionized
DOE	U.S. Department of Energy
DQOs	Data Quality Objectives
DTSC	California Department of Toxic Substances Control
ERD	Environmental Restoration Department
ES&H	Environmental Safety & Health
EPA	Environmental Protection Agency
HSU	Hydrostratigraphic unit
ID	Identification
ISM	Integrated Safety Management
IWS	Integration Work Sheet
LLNL	Lawrence Livermore National Laboratory
LSO	Livermore Site Office
MCL	Maximum Contaminant Level
MeV	Mega electron volt
Mg/kg	Milligram per kilogram
Mph	Miles per hour
Mrem/yr	Millirem per year
NAS	Naval Air Station
OSHA	Occupational Safety and Health Administration
OSP	Operational Safety Procedure
PARCC	Precision, accuracy, representativeness, comparability, and completeness
PCBs	Polychlorinated biphenyls
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
PPE	Personal protection equipment
PWS	Procured-Services Work Sheet
QA	Quality assurance
QC	Quality control
RPM	Remedial Project Manager
RWQCB	San Francisco Bay Regional Water Quality Control Board

SARA	Superfund Amendments and Reauthorization Act
SL	Screening level
SOP	Standard operating procedure
STLC	Soluble Threshold Limit Concentration
SVOCs	Semi-volatile organic compounds
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TFG-1	Treatment Facility G-1
TTLC	Total Threshold Limit Concentration
US EPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds

Figures

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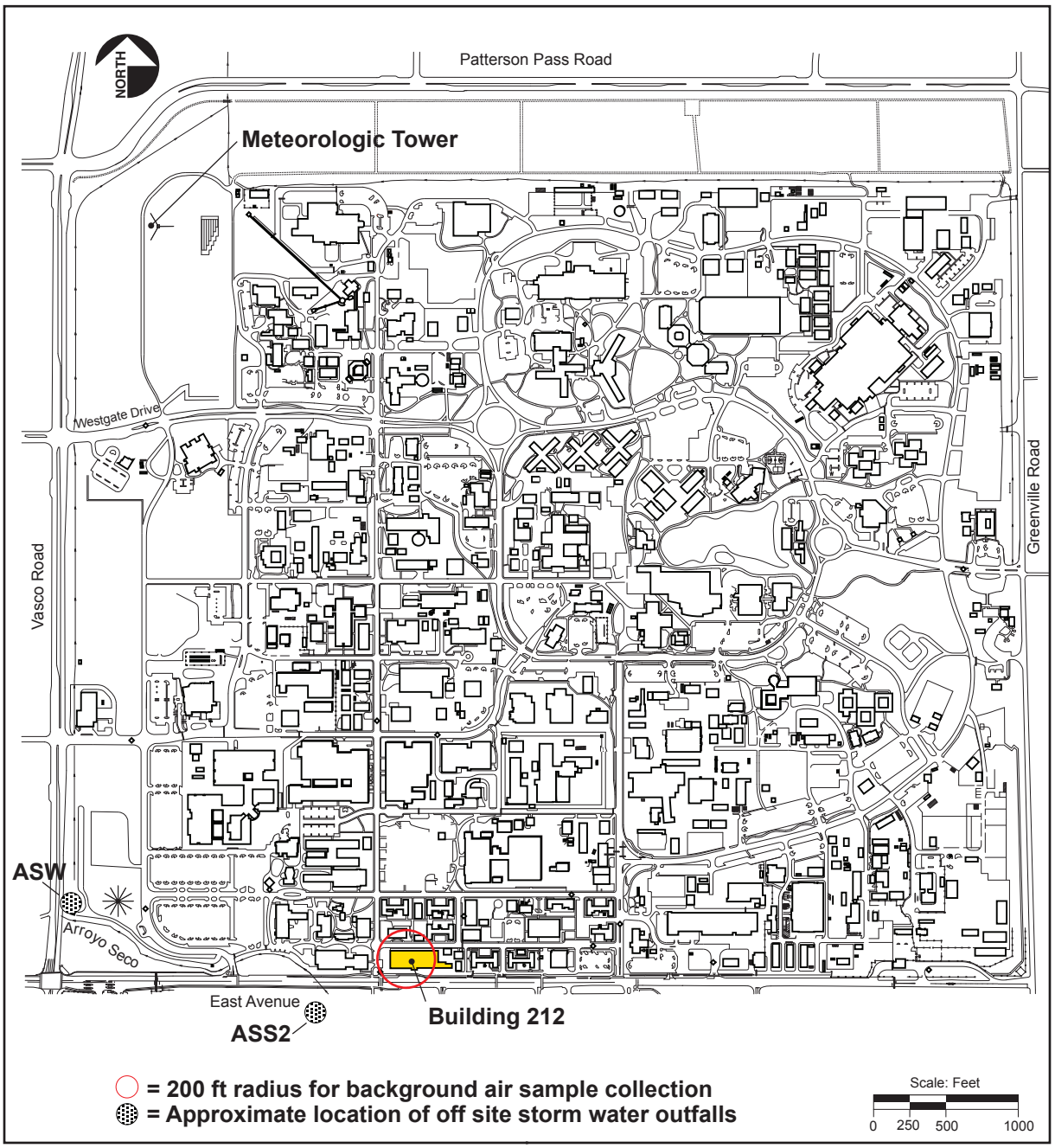

ERD-LSR-10-0001

Figure 1. Location of Building 212 at the Livermore Site, Lawrence Livermore National Laboratory (LLNL).

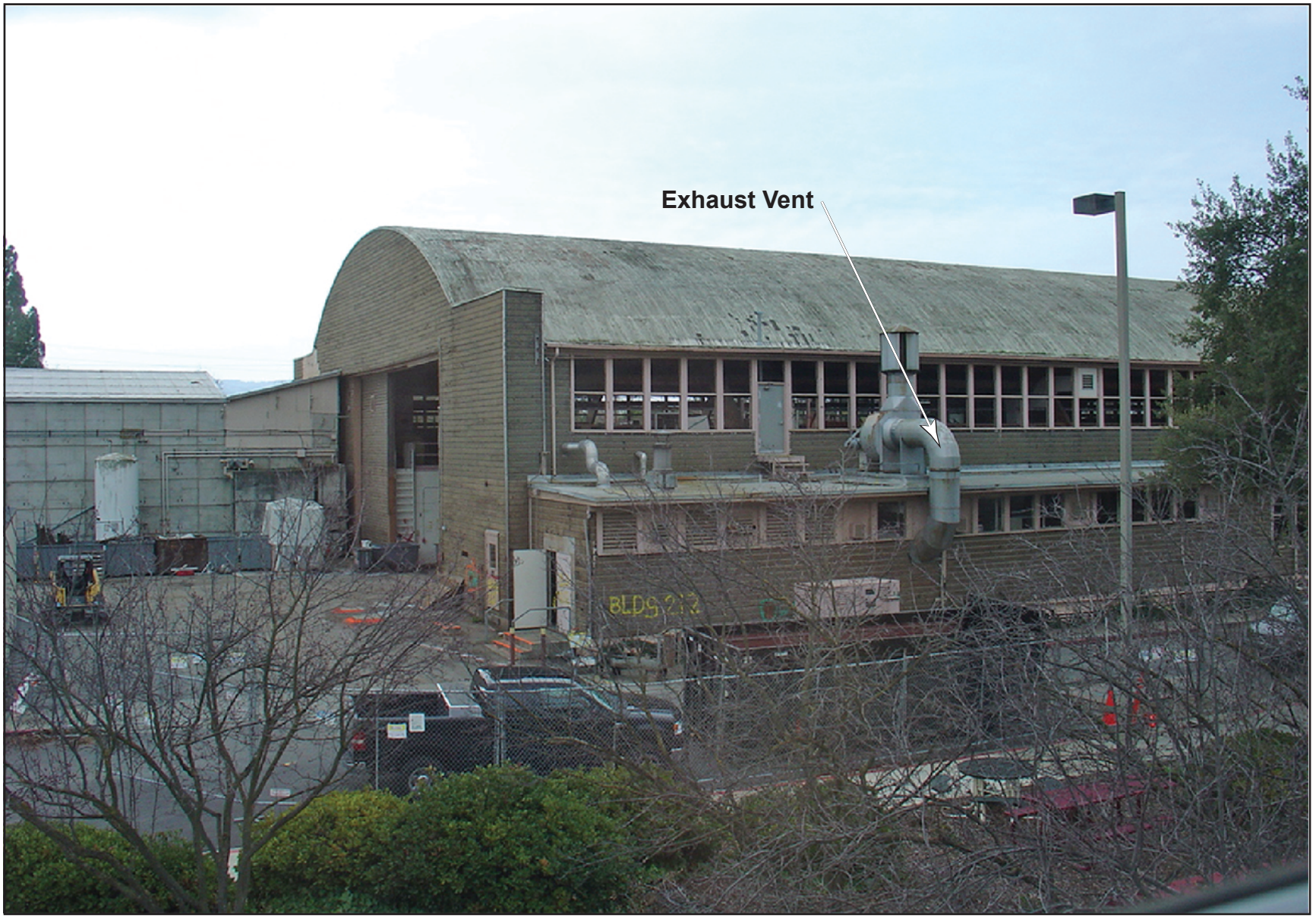

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Figure 2. Building 212 looking southwest, February 2008, LLNL.

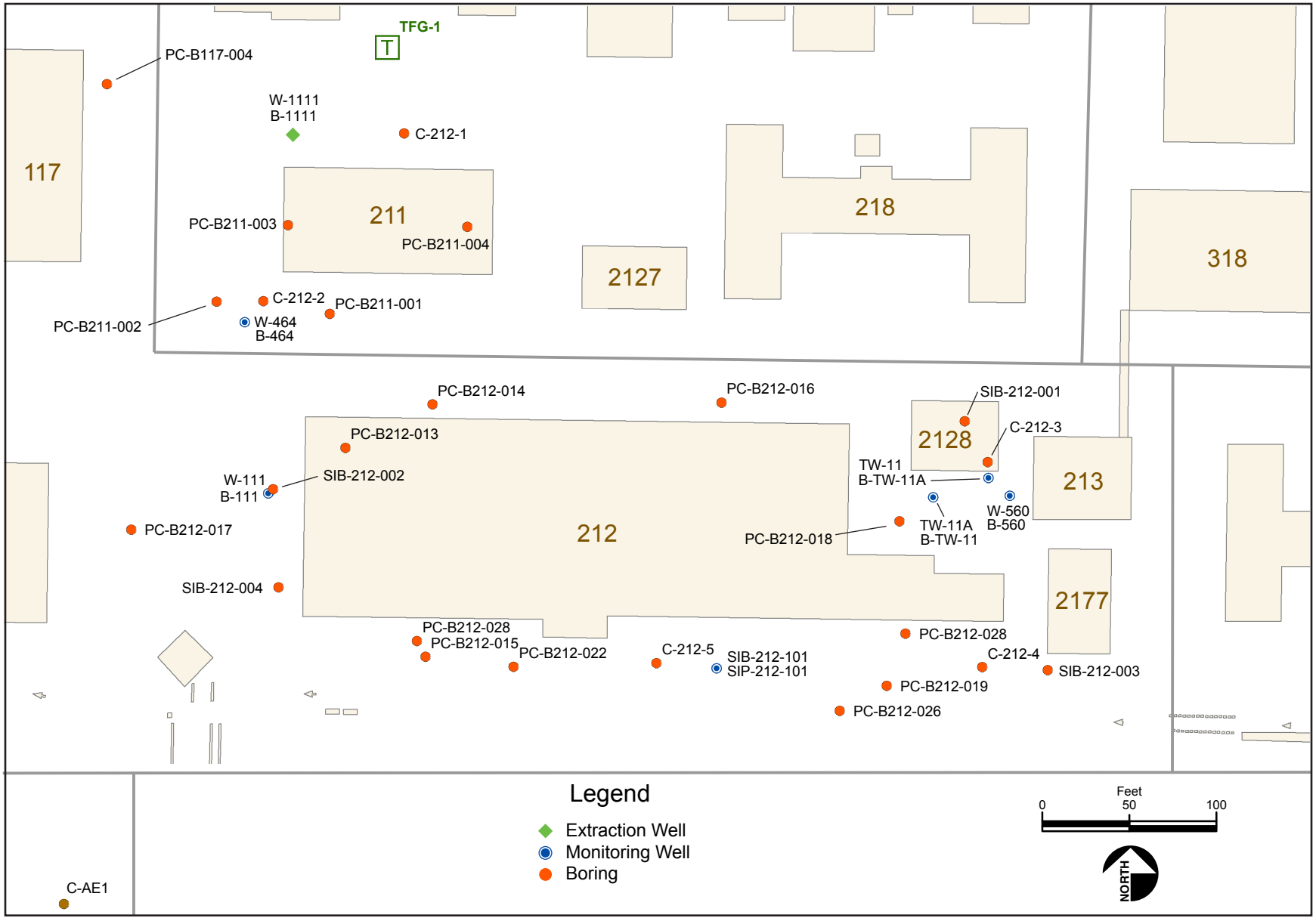

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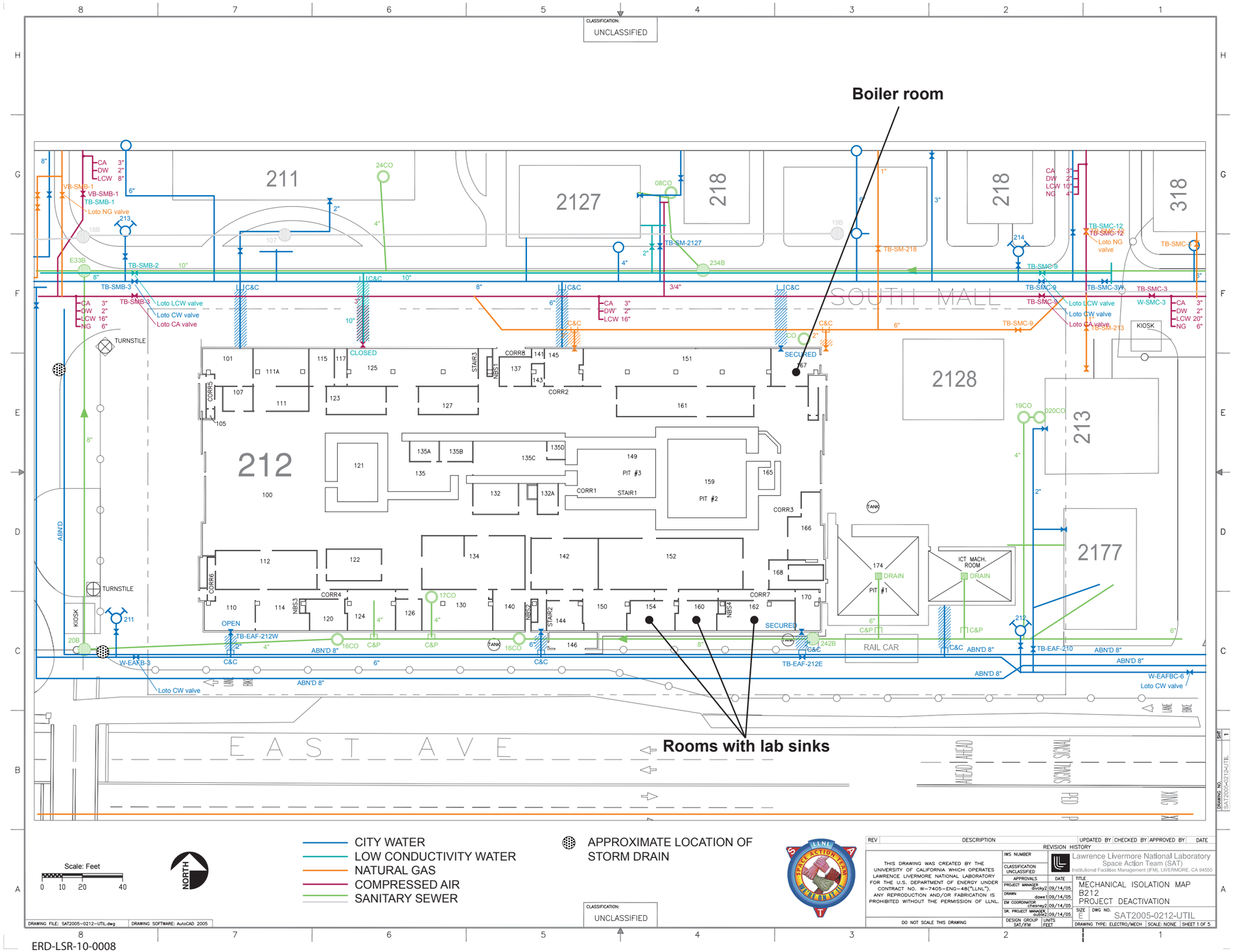
Figure 3. Borings and wells in the vicinity of Building 212, LLNL.



ERD-LSR-10-0008

Figure 4. Building 212 Area utility drawings and summary of known room activities with potential mercury sources, LLNL.

ERD-LSR-10-0005

Figure 5. Building 212 foundation looking southwest showing former vegetation area between sidewalk and building foundation, August 2008, LLNL.

ERD-LSR-10-0006

Figure 6. Building 212 foundation looking southwest showing the trench between sidewalk and foundation (excavated area), August 2008, LLNL.

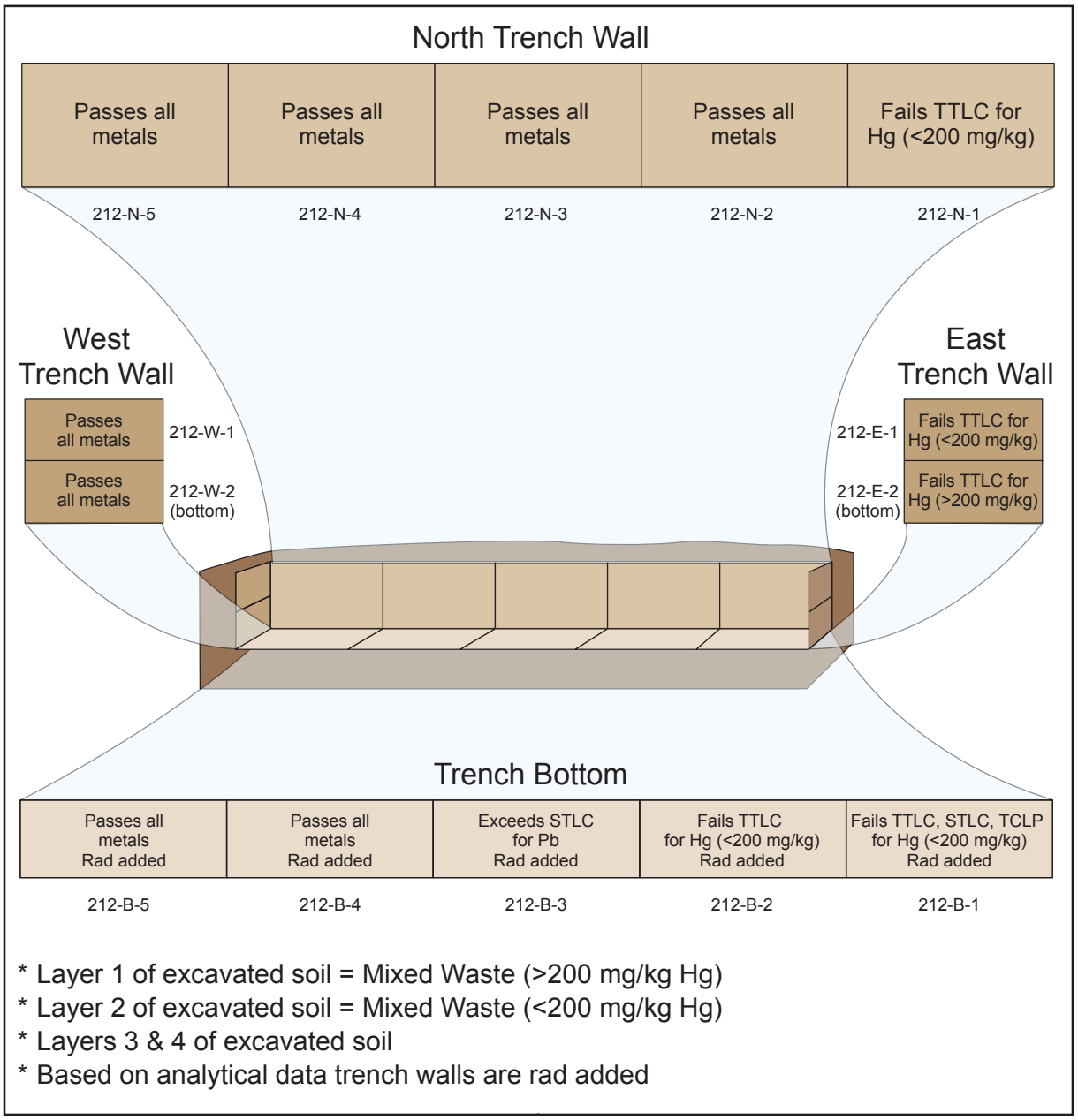


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Figure 7. Building 212 confirmation sample locations and results, LLNL (Trench location shown on Figure 6).

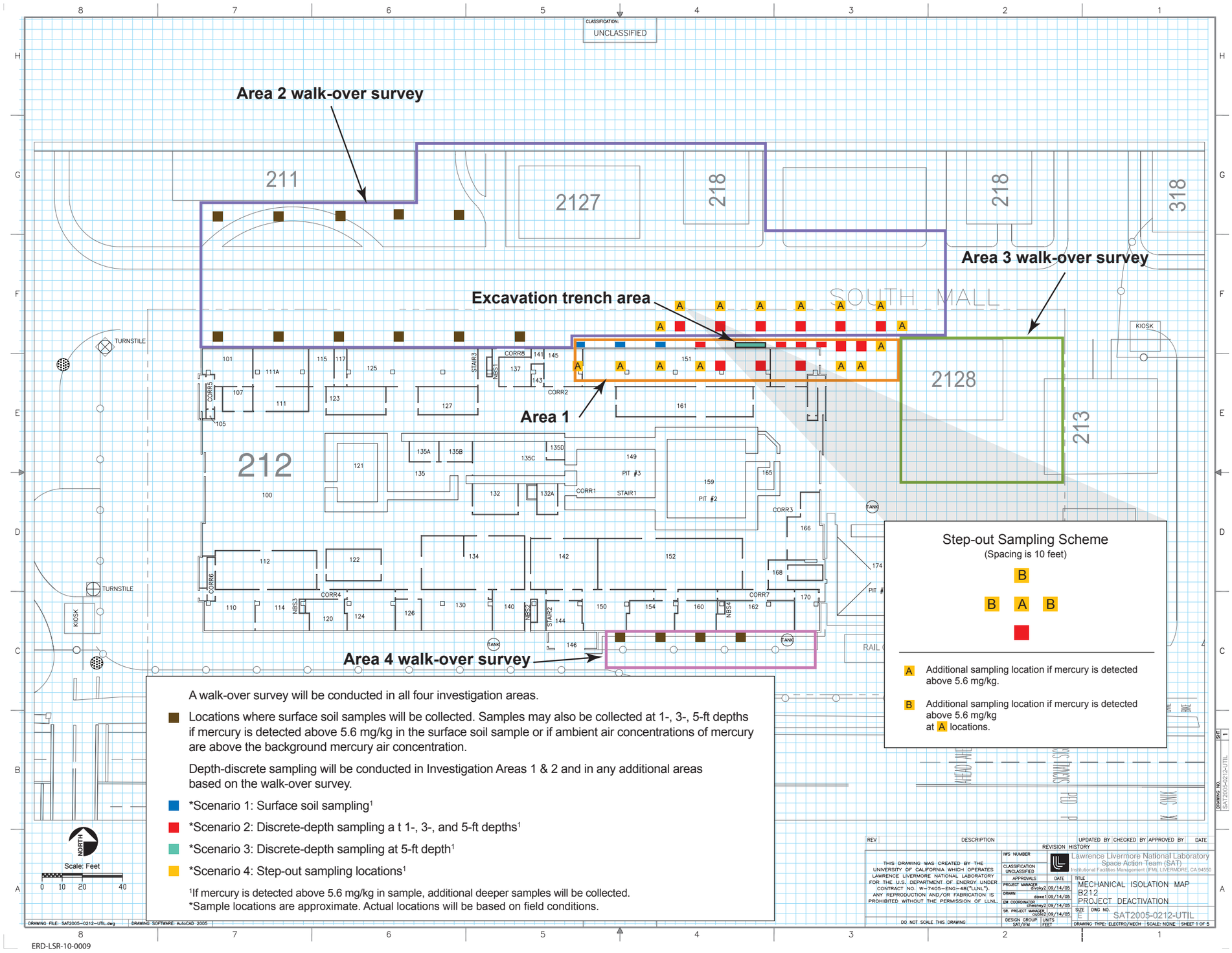

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Figure 8. Investigation areas and proposed sampling locations, Building 212 Area, LLNL.

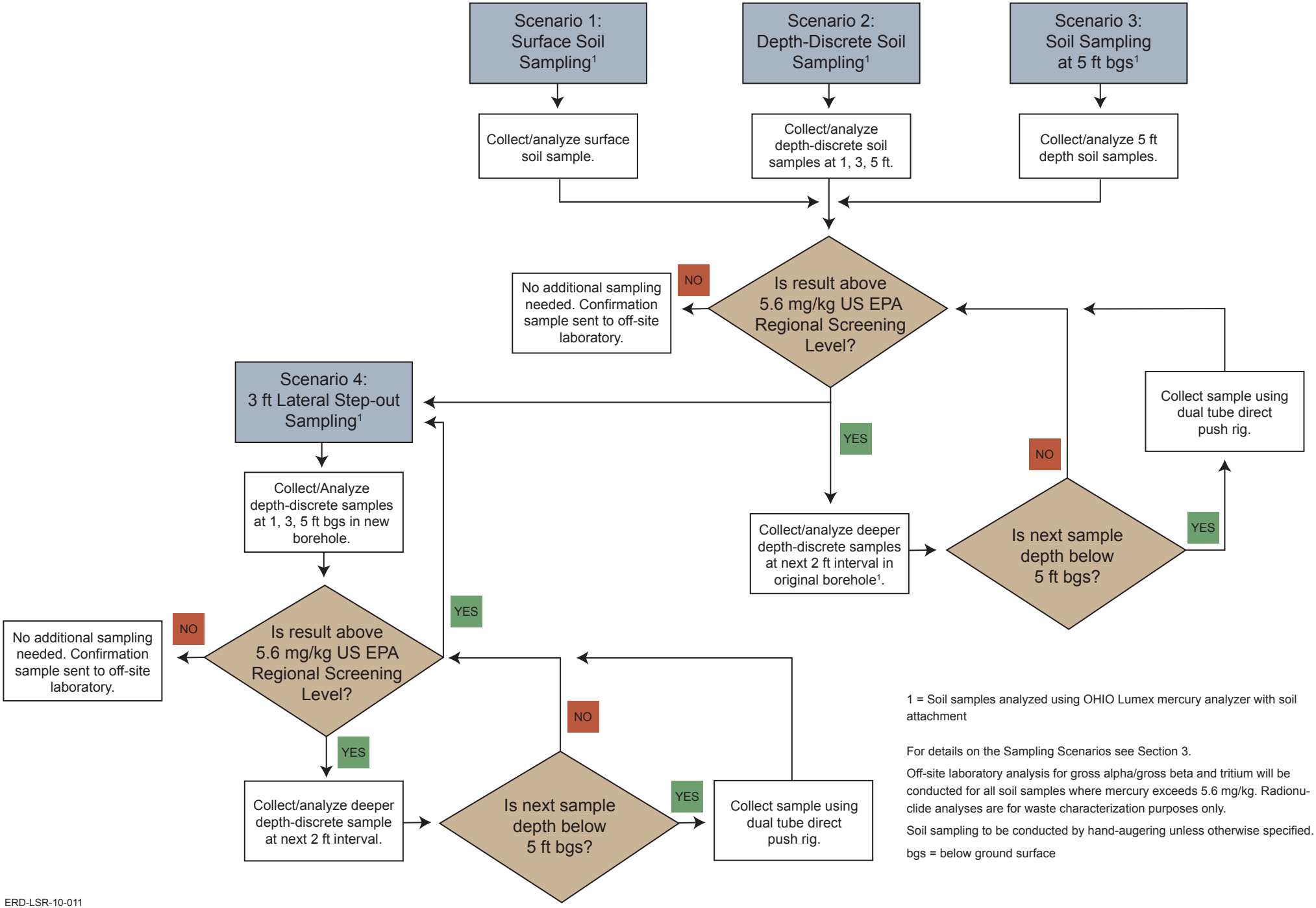
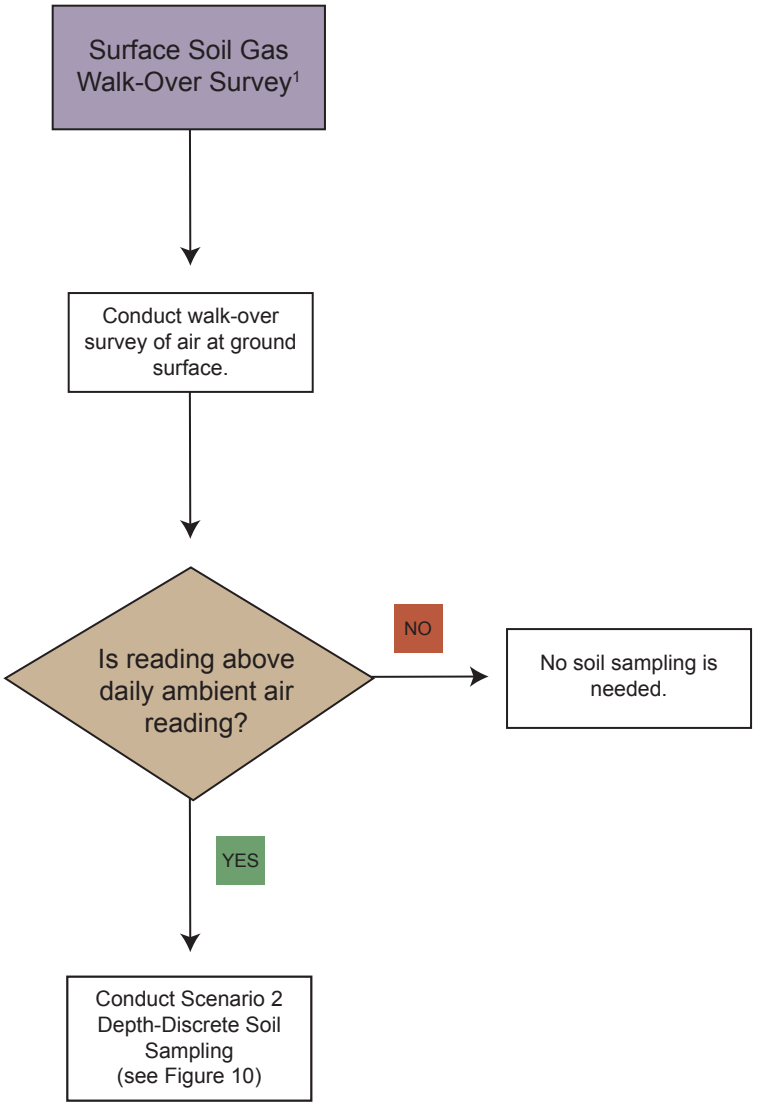


Figure 9. Proposed soil sampling scenarios for mercury investigation at Building 212, LLNL.



ERD-LSR-11-012

Figure 10. Proposed soil gas walk-over survey sampling scenario for mercury investigation at Building 212, LLNL.

Tables

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Table 1. Mercury Investigation Data Quality Objectives, Building 212 Area, LLNL.

Step 1. State the Problem. *Define the problem that necessitates the study; identify the planning team, examine budget, schedule.*

Problem: To delineate the lateral and vertical extent of mercury in the Building 212 area. Visible elemental mercury was encountered in the soil next to the building foundation during building demolition activities. Some mercury-impacted soil was removed during the demolition activities; however subsequent confirmation sampling indicates that residual mercury in soil exceeds risk-based standards, US Environmental Protection Agency Residential Screening Levels (EPA RSLs), and the extent of the mercury is not fully defined.

Available data and process knowledge suggest that mercury is concentrated beneath a forced-air vent formerly located on the north side of Building 212. However, wind and storm water runoff may have spread the mercury over a larger area. To mitigate risks that the mercury may present, the lateral and vertical extent of the mercury must be defined.

Prior activities at Building 212 included high energy physics experiments that could have produced neutron activation products (e.g., tritium) or resulted in the release of radioisotopes to the environment. The presence of the radioisotopes in the mercury-impacted area(s) could impact risks and significantly escalate the remediation costs. At this time, the likelihood of impacts in the suspected mercury release area is low, but screening for potential impacts is warranted to help manage risk and remediation uncertainties.

Planning Team: Planning is conducted by LLNL and Weiss Associates personnel with oversight from the US EPA, Region IX, San Francisco RWQCB, and the DTSC. Peter McKereghan leads the LLNL Team, and provides project oversight and senior technical review; Charlie Noyes provides project oversight and senior technical review. The Weiss Team is responsible for preparing the Work Plan and overseeing the field investigation. Michael D. Dresen, a California-licensed Professional Geologist and Certified Hydrogeologist, is the Project Manager for Weiss Associates.

Budget and Schedule: Final work plan submittal was late May 2010. Field work is scheduled for early June 2010, and the results will be reported in a summary report scheduled for submittal in early November 2010.

Step 2. Identify the Goal of the Study. *State how environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes.*

A walk-over mercury vapor survey will be conducted and soil samples will be collected from selected locations in the vicinity of the Building 212 where elemental mercury in the soil was encountered and in areas where it may have been transported by wind and stormwater runoff. A dynamic "step-out" process utilizing high sensitivity field analytical methods will be used to efficiently expand the investigation from the known impacted area. Soil samples will be analyzed for mercury to define its vertical and horizontal. Screening level gross alpha, gross beta and tritium analyses will be conducted on selected samples to determine if anthropogenic radioisotopes are co-located with the mercury. If these screening parameters are elevated with respect to site background, the impacted soil samples may also be analyzed for radionuclide speciation for waste characterization purposes. Borings will be logged for lithology.

These data will be used to help answer these primary questions:

What is the extent of mercury in soil in the vicinity of Building 212? The objectives of the investigation are to delineate the lateral and vertical extent of mercury to determine (1) if there is a threat to human health or the environment, and (2) the area impacted by mercury, so a removal action can be designed and a cost estimate for remediation can be developed.

What are the release and transport mechanisms for mercury? Data are required to determine whether wind or stormwater runoff were significant transport mechanisms for mercury and, if so, whether residual concentrations represent a threat to human health and the environment.

Are radionuclides co-located with the mercury? It is possible the prior high-energy physics operations at Building 212 resulted in the generation or release of radioisotopes or that the mercury release also contained radioisotopes. Screening level data are required to determine if radioisotopes are co-located with the mercury and to refine the site conceptual model with respect to their occurrence. Defining the full extent or detailed isotopic speciation of the isotopes, if present, is beyond the scope of this work plan.

Table 1. Mercury Investigation Data Quality Objectives, Building 212 Area, LLNL. (Continued)

Step 3. Identify Information Inputs. *Identify data & information needed to answer study questions.*
Data and information inputs include: • Site background and historical information, including previous environmental investigation data and historical photographs; • Mercury vapor walk-over survey and soil sampling at appropriate locations and depths; • Borehole logs; • Field analytical results; • Laboratory analytical results; and • Laboratory data validation.
Step 4. Define the Boundaries of the Study. *Specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference.*
The limits of the study include areas on the north and south sides of Building 212, along South Mall Street and in the vicinity of Building 2128 (Figure 8).
Step 5. Develop the Analytic Approach. *Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.*
The parameters of interest are mercury, tritium, gross alpha and gross beta as they have been found in previous investigations as described in this Work Plan in Section 2.3. The data evaluation methods are described in Section 5.
Step 6. Specify Performance or Acceptance Criteria. *Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.*
New and existing data will be accepted if they are collected and analyzed according to the specifications of this Work Plan and are validated as described in the QAPP (LLNL, 1999). If modifications to the collection or analysis procedures described in this Work Plan are necessary, these changes will be evaluated for their impact on resulting data usability. Some of the proposed analyses for these investigations are not covered in the QAPP and some do not have US EPA or other standard methods. The results of these analyses will be considered semi-quantitative and will be used primarily as indicators and for comparison with other results by the same method.
Step 7. Develop the Plan for Obtaining Data. *Select the resource-effective sampling and analysis plan that meets the performance criteria.*
This plan is described in Section 3 of this Work Plan.

Table 2. Soil Analyses for Previous Building 212 Investigations, 1984 to 2009, LLNL.

Boring/Well Identification	Year	Completion	Total Depth of Boring (ft bgs)	Anions	Metals	VOCs	BTEX	SVOCs	PCBs	Gross Alpha/ Gross Beta	Cs-137	Tritium
B-1111	1995	BH	133			x	x					
B-464	1988	BH	233		x	x	x			x	x	x
B-560	1989	BH	262.7		x	x	x			x	x	x
C-212-1	1984	BH	10.89			x						
C-212-2	1984	BH	11			x						
C-212-3	1984	BH	151			x						
C-212-4	1984	BH	11.39			x						
C-212-5	1984	BH	11			x						
SIB-212-001	1989	BH	98.3			x						x
SIB-212-002	1989	BH	100.5		x	x			x			x
SIB-212-003	1989	BH	91.3			x						x
SIB-212-004	1989	BH	96.09		x	x			x			x
SIP-212-101	1996	BH/PZ	90.5		x	x						x
TW-11	1996	MW	107		x	x		x		x		x
TW-11A	1996	MW	160		x	x		x		x		
W-111	1984	MW	117		x	x				x		x
W-1111	1997	MW	129		x	x				x		x
W-464	1988	MW	104.5	x	x	x				x		
W-560	1989	MW	206.5	x	x	x						
PC-B117-004	2000	BH	1		x	x	x					
PC-B211-001	1997	BH	2		x	x						
PC-B211-002	1997	BH	4		x					x		x
PC-B211-003	1997	BH	2		x	x				x		x
PC-B211-004	1997	BH	2		x	x				x		x
PC-B212-012	1994	BH	0		x	x	x					
PC-B212-013	1997	BH	0		x	x	x			x		x
PC-B212-014	2005	BH	4		x	x	x			x		x
PC-B212-015	2005	BH	4		x	x	x			x		x
PC-B212-016	2006	BH	4		x	x	x			x		x
PC-B212-017	2006	BH	3		x	x	x			x		x
PC-B212-018	2007	BH	0							x		x
PC-B212-019	2009	BH	0							x		x
PC-B212-020	2009	BH	0							x		x
PC-B212-021	2009	BH	0							x		x

Table 2. Soil Analyses for Previous Building 212 Investigations, 1984 to 2009, LLNL. (Continued)

Boring/Well Identification	Year	Completion	Total Depth of Boring (ft bgs)	Anions	Metals	VOCs	BTEX	SVOCs	PCBs	Gross Alpha/ Gross Beta	Cs-137	Tritium
PC-B212-022	2009	BH	0							x		x
PC-B212-023	2009	BH	0							x		x
PC-B212-024	2009	BH	3							x		x
PC-B212-025	2009	BH	3							x		x
PC-B212-026	2009	BH	3							x		x
PC-B212-027	2009	BH	3							x		x
PC-B212-028	2009	BH	3							x		x

Notes:

0 = Surface sample.
BH/PZ = Borehole/piezometer.
BTEX = Benzene, toluene, ethylebenzene, and xylene.
ft bgs = Feet below ground surface.
MW = Monitoring well.
PCBs = Polychlorinated biphenols.
PZ = Piezometer.
SVOCs = Semi-volatile organic compounds.
VOCs = Volatile organic compounds.

Table 3. Summary of Analytic Results of Soil Samples, 1984 to 1997, Building 212 Area, LLNL.

Boring Identification	Analyte	Results	Detection Limit	Units	Date Sampled	Depth (ft bgs)
B-464	Gross alpha	5	0	pCi/g	9/20/88	11.8
B-464	Gross alpha	< 4	4	pCi/g	9/21/88	96.8
B-560	Gross alpha	4	3	pCi/g	1/26/89	7.5
B-560	Gross alpha	< 4	4	pCi/g	1/26/89	21.3
B-560	Gross alpha	10	6	pCi/g	1/30/89	127.8
SIB-212-101	Gross alpha	4.2	0.97	pCi/g	3/12/96	5.4
SIB-212-101	Gross alpha	4	1.4	pCi/g	3/12/96	10.4
SIB-212-101	Gross alpha	5.7	1.2	pCi/g	3/12/96	20.4
SIB-212-101	Gross alpha	5.2	1.1	pCi/g	3/12/96	30.4
SIB-212-101	Gross alpha	3.58	0.82	pCi/g	3/12/96	40.4
SIB-212-101	Gross alpha	6.7	0.9	pCi/g	3/13/96	50.5
SIB-212-101	Gross alpha	3.7	0.8	pCi/g	3/13/96	60.4
SIB-212-101	Gross alpha	5.1	0.81	pCi/g	3/13/96	70.4
SIB-212-101	Gross alpha	5.7	1	pCi/g	3/13/96	80.4
SIB-212-101	Gross alpha	3.7	0.85	pCi/g	3/13/96	90.4
SIB-212-101	Gross alpha	4	1.5	pCi/g	3/13/96	93.4
B-464	Gross beta	15	0	pCi/g	9/20/88	11.8
B-464	Gross beta	23	0	pCi/g	9/21/88	96.8
B-560	Gross beta	13	5	pCi/g	1/26/89	7.5
B-560	Gross beta	17	5	pCi/g	1/26/89	21.3
B-560	Gross beta	14	4	pCi/g	1/30/89	127.8
SIB-212-101	Gross beta	3.71	0.93	pCi/g	3/12/96	5.4
SIB-212-101	Gross beta	4.98	0.9	pCi/g	3/12/96	10.4
SIB-212-101	Gross beta	6.71	0.84	pCi/g	3/12/96	20.4
SIB-212-101	Gross beta	7.29	0.82	pCi/g	3/12/96	30.4
SIB-212-101	Gross beta	4.83	0.63	pCi/g	3/12/96	40.4
SIB-212-101	Gross beta	9	0.92	pCi/g	3/13/96	50.5
SIB-212-101	Gross beta	5.04	0.69	pCi/g	3/13/96	60.4
SIB-212-101	Gross beta	5	0.74	pCi/g	3/13/96	70.4
SIB-212-101	Gross beta	3.08	0.84	pCi/g	3/13/96	80.4
SIB-212-101	Gross beta	6.84	0.73	pCi/g	3/13/96	90.4
SIB-212-101	Gross beta	3.86	0.86	pCi/g	3/13/96	93.4
B-464	Mercury	< 0.001	0.001	mg/L	9/20/88	11.0
B-464	Mercury	< 0.001	0.001	mg/L	9/21/88	95.3
B-560	Mercury	< 0.01	0.01	mg/L	1/26/89	7.3

Table 3. Summary of Analytic Results of Soil Samples, 1984 to 1997, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Results	Detection Limit	Units	Date Sampled	Depth (ft bgs)
SIB-212-002	Mercury	< 0.01	0.01	mg/L	5/17/89	6.0
SIB-212-002	Mercury	< 0.01	0.01	mg/L	5/17/89	11.0
SIB-212-004	Mercury	< 0.01	0.01	mg/L	5/17/89	5.8
SIB-212-101	Mercury	< 0.005	0.005	mg/L	3/12/96	5.6
SIB-212-101	Mercury	< 0.05	0.05	mg/kg	3/12/96	5.6
SIB-212-101	Mercury	< 0.005	0.005	mg/L	3/12/96	10.6
SIB-212-101	Mercury	< 0.05	0.05	mg/kg	3/12/96	10.6
SIB-212-101	Mercury	< 0.005	0.005	mg/L	3/13/96	50.8
SIB-212-101	Mercury	< 0.05	0.05	mg/kg	3/13/96	50.8
SIB-212-101	Mercury	< 0.005	0.005	mg/L	3/13/96	50.9
SIB-212-101	Mercury	< 0.05	0.05	mg/kg	3/13/96	50.9
B-464	Tritium	< 1000	1000	pCi/L	9/20/88	11.8
B-464	Tritium	< 1000	1000	pCi/L	9/21/88	96.8
B-560	Tritium	6000	1000	pCi/L	1/26/89	7.5
B-560	Tritium	7000	1000	pCi/L	1/26/89	21.3
B-560	Tritium	< 1000	1000	pCi/L	1/30/89	127.8
SIB-212-001	Tritium	3800	500	pCi/L	5/19/89	50.8
SIB-212-001	Tritium	< 1000	1000	pCi/L	5/19/89	98.0
SIB-212-002	Tritium	< 1000	1000	pCi/L	5/16/89	50.5
SIB-212-002	Tritium	< 1000	1000	pCi/L	5/16/89	100.5
SIB-212-003	Tritium	2000	500	pCi/L	5/16/89	10.8
SIB-212-003	Tritium	1000	500	pCi/L	5/16/89	20.5
SIB-212-003	Tritium	2000	500	pCi/L	5/16/89	54.8
SIB-212-003	Tritium	1000	500	pCi/L	5/16/89	90.8
SIB-212-004	Tritium	3000	500	pCi/L	5/18/89	50.8
SIB-212-004	Tritium	2000	500	pCi/L	5/18/89	95.5
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	5.2
SIB-212-101	Tritium	650	140	pCi/L	3/12/96	5.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	10.2
SIB-212-101	Tritium	360	160	pCi/L	3/12/96	10.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	20.2
SIB-212-101	Tritium	400	160	pCi/L	3/12/96	20.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	30.2
SIB-212-101	Tritium	960	160	pCi/L	3/12/96	30.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	40.2

Table 3. Summary of Analytic Results of Soil Samples, 1984 to 1997, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Results	Detection Limit	Units	Date Sampled	Depth (ft bgs)
SIB-212-101	Tritium	2040	160	pCi/L	3/12/96	40.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	50.3
SIB-212-101	Tritium	2900	170	pCi/L	3/13/96	50.4
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	60.2
SIB-212-101	Tritium	5140	160	pCi/L	3/13/96	60.3
SIB-212-101	Tritium	1.5	1	pCi/g	3/12/96	70.2
SIB-212-101	Tritium	7000	900	pCi/L	3/12/96	70.2
SIB-212-101	Tritium	9590	160	pCi/L	3/13/96	70.3
SIB-212-101	Tritium	2	1	pCi/g	3/12/96	80.2
SIB-212-101	Tritium	8000	900	pCi/L	3/12/96	80.2
SIB-212-101	Tritium	9300	170	pCi/L	3/13/96	80.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	90.2
SIB-212-101	Tritium	9990	150	pCi/L	3/13/96	90.3
SIB-212-101	Tritium	< 1	1	pCi/g	3/12/96	93.2
SIB-212-101	Tritium	2110	160	pCi/L	3/13/96	93.3

Notes:

ft bgs = Feet below ground surface.
mg/L = Milligrams per liter.
mg/kg = Milligrams per kilogram.
pCi/L = Picocuries per liter.
pCi/g = Picocuries per gram.

Table 4. Summary of Analytic Results for Asphalt and Soil Samples from Pre-Construction Borings (PC-212), 1997 to 2009, Building 212 Area, LLNL.

Boring Identification	Analyte	Result	Detection Limit	Units	Date Sampled	Depth (ft bgs)	Matrix
PC-B212-019	Gross alpha	< 2.7	2.7	pCi/g	3/4/09	0	AS
PC-B212-020	Gross alpha	< 2.7	2.7	pCi/g	3/4/09	0	AS
PC-B212-021	Gross alpha	< 2.64	2.64	pCi/g	3/4/09	0	AS
PC-B212-022	Gross alpha	< 2.58	2.58	pCi/g	3/4/09	0	AS
PC-B212-023	Gross alpha	< 2.85	2.85	pCi/g	3/4/09	0	AS
PC-B212-019	Gross beta	< 4.4	4.4	pCi/g	3/4/09	0	AS
PC-B212-020	Gross beta	< 4.43	4.43	pCi/g	3/4/09	0	AS
PC-B212-021	Gross beta	< 4.36	4.36	pCi/g	3/4/09	0	AS
PC-B212-022	Gross beta	< 4.21	4.21	pCi/g	3/4/09	0	AS
PC-B212-023	Gross beta	< 4.7	4.7	pCi/g	3/4/09	0	AS
PC-B212-019	Tritium	< 2.9	2.9	pCi/g	3/4/09	0	AS
PC-B212-020	Tritium	< 2.28	2.28	pCi/g	3/4/09	0	AS
PC-B212-021	Tritium	< 1.83	1.83	pCi/g	3/4/09	0	AS
PC-B212-022	Tritium	< 1.96	1.96	pCi/g	3/4/09	0	AS
PC-B212-023	Tritium	< 1.88	1.88	pCi/g	3/4/09	0	AS
PC-B212-013	Gross alpha	< 1.9	1.9	pCi/g	12/2/97	0	SO
PC-B212-013	Gross alpha	3.5	2.8	pCi/g	12/2/97	0	SO
PC-B212-014	Gross alpha	< 3.4	3.4	pCi/g	11/28/05	4	SO
PC-B212-015	Gross alpha	< 2.3	2.3	pCi/g	12/16/05	4	SO
PC-B212-016	Gross alpha	< 3.2	3.2	pCi/g	1/24/06	4	SO
PC-B212-017	Gross alpha	< 3.4	3.4	pCi/g	3/1/06	3	SO
PC-B212-017	Gross alpha	< 3.8	3.8	pCi/g	3/1/06	3	SO
PC-B212-018	Gross alpha	< 2.5	2.5	pCi/g	9/27/07	4	SO
PC-B212-024	Gross alpha	< 2.56	2.56	pCi/g	3/4/09	3	SO
PC-B212-025	Gross alpha	< 2.39	2.39	pCi/g	3/4/09	3	SO
PC-B212-026	Gross alpha	< 2.53	2.53	pCi/g	3/4/09	3	SO
PC-B212-027	Gross alpha	< 2.71	2.71	pCi/g	3/4/09	3	SO
PC-B212-028	Gross alpha	< 2.27	2.27	pCi/g	3/4/09	3	SO
PC-B212-028	Gross alpha	< 2.69	2.69	pCi/g	3/4/09	3	SO
PC-B212-013	Gross beta	< 3.2	3.2	pCi/g	12/2/97	0	SO
PC-B212-013	Gross beta	4.1	3	pCi/g	12/2/97	0	SO
PC-B212-014	Gross beta	< 3.7	3.7	pCi/g	11/28/05	4	SO
PC-B212-015	Gross beta	4.1	1.7	pCi/g	12/16/05	4	SO
PC-B212-016	Gross beta	4.1	3.1	pCi/g	1/24/06	4	SO

Table 4. Summary of Analytic Results for Asphalt and Soil Samples from Pre-Construction Borings (PC-212), 1997 to 2009, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Result	Detection Limit	Units	Date Sampled	Depth (ft bgs)	Matrix
PC-B212-017	Gross beta	3.2	2.6	pCi/g	3/1/06	3	SO
PC-B212-017	Gross beta	< 3.8	3.8	pCi/g	3/1/06	3	SO
PC-B212-018	Gross beta	4.6	2.6	pCi/g	9/27/07	4	SO
PC-B212-024	Gross beta	< 4.21	4.21	pCi/g	3/4/09	3	SO
PC-B212-025	Gross beta	< 3.91	3.91	pCi/g	3/4/09	3	SO
PC-B212-026	Gross beta	< 4.12	4.12	pCi/g	3/4/09	3	SO
PC-B212-027	Gross beta	< 4.46	4.46	pCi/g	3/4/09	3	SO
PC-B212-028	Gross beta	< 3.71	3.71	pCi/g	3/4/09	3	SO
PC-B212-028	Gross beta	< 4.35	4.35	pCi/g	3/4/09	3	SO
PC-B212-012	Mercury	< 0.005	0.005	mg/L	12/5/94	0	SO
PC-B212-012	Mercury	< 0.05	0.05	mg/kg	12/5/94	0	SO
PC-B212-013	Mercury	< 0.005	0.005	mg/L	12/4/97	0	SO
PC-B212-014	Mercury	< 0.05	0.05	mg/L	11/28/05	4	SO
PC-B212-015	Mercury	< 0.05	0.05	mg/L	12/16/05	4	SO
PC-B212-016	Mercury	< 0.005	0.005	mg/L	1/24/06	4	SO
PC-B212-017	Mercury	< 0.05	0.05	mg/L	3/1/06	3	SO
PC-B212-017	Mercury	< 0.05	0.05	mg/L	3/1/06	3	SO
PC-B212-013	Mercury	0.058	0.05	mg/kg	12/4/97	0	SO
PC-B212-014	Mercury	0.03	0.0049	mg/kg	11/28/05	4	SO
PC-B212-015	Mercury	0.21	0.0098	mg/kg	12/16/05	4	SO
PC-B212-016	Mercury	0.033	0.005	mg/kg	1/24/06	4	SO
PC-B212-017	Mercury	0.042	0.005	mg/kg	3/1/06	3	SO
PC-B212-017	Mercury	0.038	0.0049	mg/kg	3/1/06	3	SO
PC-B212-013	Potassium 40	9.2	1.37	pCi/g	12/2/97	0	SO
PC-B212-013	Potassium 40	3.7	1.37	pCi/g	12/2/97	0	SO
PC-B212-014	Radiation scan	< 100	100	DPM/g	11/28/05	4	SO
PC-B212-013	Radium 226	0.34	0.29	pCi/g	12/2/97	0	SO
PC-B212-013	Radium 228	0.46	0.26	pCi/g	12/2/97	0	SO
PC-B212-013	Radium 228	< 0.26	0.26	pCi/g	12/2/97	0	SO
PC-B212-013	Tritium	< 5	5	pCi/g	12/2/97	0	SO
PC-B212-013	Tritium	< 4.9	4.9	pCi/g	12/2/97	0	SO
PC-B212-014	Tritium	< 4.4	4.4	pCi/g	11/28/05	4	SO
PC-B212-015	Tritium	4.6	3.6	pCi/g	12/16/05	4	SO
PC-B212-016	Tritium	< 3.7	3.7	pCi/g	1/24/06	4	SO

Table 4. Summary of Analytic Results for Asphalt and Soil Samples from Pre-Construction Borings (PC-212), 1997 to 2009, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Result	Detection Limit	Units	Date Sampled	Depth (ft bgs)	Matrix
PC-B212-017	Tritium	< 4.9	4.9	pCi/g	3/1/06	3	SO
PC-B212-017	Tritium	< 4.8	4.8	pCi/g	3/1/06	3	SO
PC-B212-018	Tritium	62	2.5	pCi/g	9/27/07	4	SO
PC-B212-024	Tritium	< 1.98	1.98	pCi/g	3/4/09	3	SO
PC-B212-025	Tritium	< 2.06	2.06	pCi/g	3/4/09	3	SO
PC-B212-026	Tritium	< 1.92	1.92	pCi/g	3/4/09	3	SO
PC-B212-027	Tritium	< 2.19	2.19	pCi/g	3/4/09	3	SO
PC-B212-028	Tritium	< 2.07	2.07	pCi/g	3/4/09	3	SO
PC-B212-028	Tritium	< 1.95	1.95	pCi/g	3/4/09	3	SO
PC-B212-013	Uranium 235 by mass measurement	< 0.06	0.06	pCi/g	12/2/97	0	SO

Notes:

AS = Asphalt.
ft bgs = Feet below ground surface.
mg/L = Milligrams per liter.
mg/kg = Milligrams per kilogram.
pCi/L = Picocuries per liter.
pCi/g = Picocuries per gram.
SO = Soil.
0 = Surface soil sample.

Table 5. Summary of Analytic Results of Ground Water Samples, 1983 to 2009, Building 212 Area, LLNL.

Boring Identification	Analyte	Results	Units	Date Sampled
TW-11	Mercury	< 1.00E-04	mg/L	4/22/83
TW-11	Mercury	< 1.00E-04	mg/L	3/29/84
TW-11	Mercury	< 1.00E-04	mg/L	11/27/84
TW-11	Mercury	< 1.00E-04	mg/L	11/27/84
TW-11	Mercury	< 0.0002	mg/L	5/4/95
TW-11	Mercury	< 0.0002	mg/L	12/10/09
TW-11A	Mercury	< 1.00E-04	mg/L	11/20/84
TW-11A	Mercury	< 0.0002	mg/L	8/8/95
TW-11A	Mercury	< 0.0002	mg/L	12/10/09
W-111	Mercury	< 0.0002	mg/L	5/4/95
W-111	Mercury	< 0.0002	mg/L	12/16/09
W-464	Mercury	0.0003	mg/L	12/1/89
W-464	Mercury	< 0.001	mg/L	8/24/90
W-464	Mercury	< 0.0002	mg/L	5/9/95
W-464	Mercury	< 0.0002	mg/L	12/10/09
W-560	Mercury	< 1.00E-04	mg/L	3/7/89
TW-11	Gross alpha	< 3	pCi/L	11/27/84
TW-11	Gross alpha	< 3	pCi/L	11/27/84
TW-11	Gross alpha	10.6	pCi/L	2/9/96
TW-11	Gross alpha	6.33	pCi/L	12/10/09
TW-11A	Gross alpha	< 4	pCi/L	11/20/84
TW-11A	Gross alpha	< 6.1	pCi/L	2/9/96
TW-11A	Gross alpha	2.95	pCi/L	12/10/09
W-111	Gross alpha	7.3	pCi/L	2/9/96
W-111	Gross alpha	5	pCi/L	5/20/96
W-111	Gross alpha	4.61	pCi/L	12/16/09
W-464	Gross alpha	2	pCi/L	6/5/96
W-464	Gross alpha	< 2	pCi/L	12/10/09
W-560	Gross alpha	< 4.9	pCi/L	2/9/96
TW-11	Gross beta	< 4	pCi/L	11/27/84
TW-11	Gross beta	< 4	pCi/L	11/27/84
TW-11	Gross beta	7.6	pCi/L	2/9/96
TW-11	Gross beta	3.61	pCi/L	12/10/09

Table 5. Summary of Analytic Results of Ground Water Samples, 1983 to 2009, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Results	Units	Date Sampled
TW-11A	Gross beta	8	pCi/L	11/20/84
TW-11A	Gross beta	< 5	pCi/L	2/9/96
TW-11A	Gross beta	3.25	pCi/L	12/10/09
W-111	Gross beta	< 4.9	pCi/L	2/9/96
W-111	Gross beta	< 6	pCi/L	5/20/96
W-111	Gross beta	< 3	pCi/L	12/16/09
W-464	Gross beta	< 4.3	pCi/L	6/5/96
W-464	Gross beta	< 3	pCi/L	12/10/09
W-560	Gross beta	< 3.9	pCi/L	2/9/96
SIP-212-101	Tritium	1900	pCi/L	5/31/96
SIP-212-101	Tritium	1800	pCi/L	8/27/96
SIP-212-101	Tritium	< 210	pCi/L	2/7/97
SIP-212-101	Tritium	300	pCi/L	4/14/97
SIP-212-101	Tritium	600	pCi/L	3/19/98
SIP-212-101	Tritium	< 129	pCi/L	7/13/98
SIP-212-101	Tritium	140	pCi/L	3/3/99
SIP-212-101	Tritium	151	pCi/L	9/15/99
SIP-212-101	Tritium	182	pCi/L	3/3/00
SIP-212-101	Tritium	114	pCi/L	3/9/01
SIP-212-101	Tritium	188	pCi/L	3/15/02
TW-11	Tritium	< 1000	pCi/L	11/27/84
TW-11	Tritium	< 1000	pCi/L	11/27/84
TW-11	Tritium	650	pCi/L	2/9/96
TW-11	Tritium	600	pCi/L	4/14/97
TW-11	Tritium	231	pCi/L	6/4/99
TW-11A	Tritium	< 1000	pCi/L	11/20/84
TW-11A	Tritium	200	pCi/L	2/9/96
W-111	Tritium	520	pCi/L	2/9/96
W-111	Tritium	900	pCi/L	5/20/96
W-111	Tritium	597	pCi/L	12/4/98
W-111	Tritium	303	pCi/L	12/19/00
W-111	Tritium	281	pCi/L	11/15/01
W-111	Tritium	268	pCi/L	12/4/02
W-111	Tritium	158	pCi/L	10/29/03
W-111	Tritium	< 100	pCi/L	12/1/04
W-111	Tritium	162	pCi/L	11/27/06
W-464	Tritium	2000	pCi/L	2/27/91

Table 5. Summary of Analytic Results of Ground Water Samples, 1983 to 2009, Building 212 Area, LLNL. (Continued)

Boring Identification	Analyte	Results	Units	Date Sampled
W-464	Tritium	900	pCi/L	6/5/96
W-560	Tritium	< 200	pCi/L	2/21/91
W-560	Tritium	< 170	pCi/L	2/9/96

Table 6. Confirmation Sample Results from Soil Removal, September 2008, Building 212 Area, LLNL.

Sample Identification	Date	Screening levels	TTLC (mg/kg) Mercury (20 mg/kg)	STLC (mg/kg) Mercury (0.20 mg/L)	TCLP (mg/L) Mercury (0.2 mg/L)	Gross Alpha (pCi/g) NE	Gross Beta (pCi/g) NE	Tritium (pCi/L) NE
212-B-1	9/15/08		**32.2**	**0.565**	**0.269**	11.1	17.4	-0.348 U
212-B-2	9/15/08		**131**	<0.200	0.0799	9.43	19.9	-0.373 U
212-B-3	9/15/08		7.58	<0.200	0.0105	8.95	17.2	-0.19 U
212-B-4	9/15/08		7.83	<0.200	<0.002	9.39	17.2	0.209 U
212-B-5	9/15/08		3.32	<0.200	<0.002	9.96	17.7	-0.115 U
212-E-1	9/15/08		**69.4**	<0.200	0.0162	NA	NA	NA
212-E-2	9/15/08		**291**	<0.200	0.0765	NA	NA	NA
212-W-1	9/15/08		2.35	<0.200	<0.002	NA	NA	NA
212-W-1RP	9/15/08		5.15	<0.200	<0.002	NA	NA	NA
212-W-2	9/15/08		6.32	<0.200	<0.002	NA	NA	NA
212-N-1	9/15/08		**137**	<0.200	<0.002	NA	NA	NA
212-N-2	9/15/08		15	<0.200	<0.002	NA	NA	NA
212-N-3	9/15/08		7.75	<0.200	<0.002	NA	NA	NA
212-N-4	9/15/08		0.802	<0.200	<0.002	NA	NA	NA
212-N-5	9/15/08		0.185	<0.200	<0.002	NA	NA	NA

Notes:

Bold = If above the screening level.
mg/L = Milligrams per liter.
mg/kg = Milligrams per kilogram.
NA = Not analyzed.
NE = Not established.
pCi/L = Picocuries per liter.
pCi/g = Picocuries per gram.
STLC = Soluble Threshold Limit Concentration.
TTLC = Total Threshold Limit Concentration.
TCLP = Toxicity Characteristic Leaching Procedure.
U = Not detected.

Table 7. Analytic Results for Waste Characterization from Soil Removal, September 2008, Building 212 Area, LLNL.

Analyte	Sample Identification Screening level	212-1 8/19/08	212-2 8/19/08	212-5 8/19/08
Mercury (mg/kg)	TTLC (20 mg/kg)	**2490**	**23.8**	9.26
Mercury (mg/L)	STLC (0.20 mg/L)	**1.93**	<0.200	<0.200
Mercury (mg/L)	TCLP (0.2 mg/L)	**0.343**	0.00322	0.0541
Gross Alpha	NE	**11.3**	**7.13**	**8.76**
Gross Beta	NE	**19.6**	**14.3**	**17.2**
Tritium (pCi/L)	NE	5.39	-0.386 U	-0.376 u
Rad Alpha Spec Analysis				
Americium-241		-0.0187 U	0.0304 U	0.022 U
Americium-243		0.0142 U	0.105 X	0.0699 U
Plutonium-238		0.000856 U	0.00558 U	-0.0196 U
Plutonium 239/240		0.0483 U	0.0871	-0.00736 U
Thorium-228		**0.74**	**1.03**	**0.773**
Thorium-230		**0.678**	**0.984**	**0.771**
Thorium-232		**0.649**	**0.848**	**1.05**
Uranium-233/234		**0.672**	**0.469**	**0.637**
Uranium-235/236		0.0646 U	0.0266 U	**0.09**
Uranium-238		**0.862**	**0.646**	**0.655**
Rad Gamma Spec Analysis				
Actinium-228		**0.697**	**0.652**	**0.828**
Americium-241		-0.0119 U	-0.0269 U	-0.0569 U
Antimony-124		0.0435 U	0.035 U	0.00257 U
Antimony-125		-0.0164 U	-0.0163 U	-0.016 U
Barium-133		-0.00402 U	0.00636 U	0.00897 U
Barium-140		0.0391 U	-0.916 U	-0.213 U
Beryllium-7		-0.0302 U	-0.0614 U	-0.103 U
Bismuth-212		0.00 UI	**0.353**	**0.549**
Bismuth-214		**0.506**	**0.556**	**0.505**
Cerium-139		-0.00709 U	0.0119 U	-0.0127 U
Cerium-141		-0.0542 U	0.0182 U	-0.00422 U
Cerium-144		0.00149 U	-0.165 U	0.0253 U
Cesium-34		0.0379 U	0.0039 U	0.00553 U
Cesium-136		0.156 U	-0.347 U	0.136 U
Cesium-137		**0.588**	**0.124**	-0.00258 U
Chromium-51		0.411 U	-0.0491 U	0.227 U
Coblat-56		-0.0102 U	0.0155 U	0.0129 U
Cobalt-57		0.0019U	0.00144 U	-0.0104 U
Cobalt-58		-0.0425 U	0.0153 U	-0.053 U
Cobalt-60		0.016 U	0.00514 U	0.0134 U
Europium-152		-0.0212 U	0.0332 U	0.0186 U
Europium-154		-0.119 U	-0.0631 U	-0.0669 U
Europium-155		0.0887 U	0.102 U	0.0431 U
Iridium-192		0.0169 U	0.00983 U	-0.0233 U
Iron-59		-0.0287 U	0.069 U	-0.0711 U

Table 7. Analytic Results for Waste Characterization from Soil Removal, September 2008, Building 212 Area, LLNL. (Continued)

Analyte	Sample Identification Screening level	212-1 8/19/08	212-2 8/19/08	212-5 8/19/08
Lead-210		-2.62 U	0.330 U	-2.01 U
Lead-212		**0.625**	**0.684**	**0.679**
Lead-214		**0.547**	**0.612**	**0.603**
Manganese-54		0.00399 U	0.051 U	0.0106 U
Mercury-203		0.00212 U	0.0589 U	-0.0203 U
Neodymium-147		1.61 U	-5.65 U	-0.909 U
Neptunium-239		0.0559 U	0.0312 U	0.0515 U
Niobium-94		0.00913 U	-0.0139 U	-0.0192 U
Niobium-95		0.0836 U	0.00 UI	0.0324 U
Potassium-40		**13.2**	**14.4**	**15.2**
Promethium-144		0.00395 U	0.0298 U	0.0113 U
Promethium-146		0.00513 U	-0.0319 U	0.0025 U
Radium-228		**0.697**	**0.652**	**0.828**
Ruthenium-106		0.0579 U	0.000312 U	0.0894 U
Silver-110m		0.000923 U	-0.00786 U	-0.0245 U
Sodium-22		-0.0411 U	-0.0337 U	-0.0268 U
Thallium-208		**0.211**	**0.306**	**0.196**
Thorium-230		**0.506**	**0.556**	**0.505**
Thorium-234		0.248 U	0.00 UI	0.0629 U
Tin-113		0.0339 U	-0.0499 U	0.012 U
Uranium-235		0.053 U	-0.0532 U	0.0197 U
Uranium-238		0.248 U	0.00 UI	0.0629 U
Yttrjum-88		0.0104 U	-0.0265 U	-0.00125 U
Zinc-65		-0.0597 U	-0.0565 U	0.00513 U
Zirconium-95		0.0466 U	0.144 U	0.0621 U

Notes:

NA = Not analyzed.
NE = Not established.
Bold = If above the mercury screening level. Radionuclides are bold if detected.
Gross Alpha and Gross Beta screening levels are calculated background levels.
mg/L = Milligrams per liter.
mg/kg = Milligrams per kilogram.
pCi/L = Picocuries per liter.
pCi/g = Picocuries per gram.
SO = Soil.
Units are pCi/g unless otherwise noted.
U = Not detected.

Table 8. Building 212 Demolition Chronology.

April 17, 2008	**Mercury in the soil was identified during the Building 212 Demolition Project. The Alameda County Environmental Health Department, California Office of Emergency Services, National Response Center, U.S. EPA, and (RWQCB) were notified.**
April 28, 2008	**Notified the RWQCB of the discovery of mercury in soil at Building 212.**
May 1, 2008	**Notified the Alameda County Environmental Health Department of the discovery of mercury in soil at Building 212.**
May 9, 2008	**DOE Livermore Site Office (LSO) discussed the discovery of mercury at the Remedial Project Managers' (RPM) meeting with the EPA, RWQCB, and the DTSC.**
May 12, 2008	**Notified the DTSC of the discovery of mercury in soil at Building 212.**
June 25, 2008	**The regulatory agencies concurred with DOE's decision to initiate the removal of the mercury and requested a written work plan be submitted for approval.**
July 10, 2008	**The work plan was submitted to the regulatory agencies.**
August 19, 2008	**Initiated the time critical soil removal action for mercury at Building 212 (Figures 5 and 6). Sampled soil as it was being excavated to characterize nature and extent of contamination.**
August 22, 2008	**Concluded excavation to boundaries described in the work plan.**
September 15, 2008	**Sampled soil in a trench along the north side of Building 212 to characterize remaining soil and determine if contamination was still present.**
October 30, 2008	**DOE LSO discussed the status of the time-critical removal action at the RPM meeting and received approval from the EPA, RWQCB, and DTSC to temporarily fill in and cover the excavation.**
November 5, 2008	**Confirmation sample results indicate the presence of low-level radioactivity along with the mercury in some locations within the trench (Figure 7).**
January 13, 2009	**Lined the excavation with plastic and backfilled with clean soil.**
January 15, 2009	**Covered the excavation area with concrete.**

Table 9. Summary of Analytic Results of Storm Water Runoff Samples, 1991 to 2009, LLNL.

Sample Idenitification	Analyte	Results	Units	Date Sampled
L-ASS2-RO	Mercury	< 0.0005	mg/L	2/27/91
L-ASS2-RO	Mercury	< 0.0005	mg/L	3/1/91
L-ASS2-RO	Mercury	< 0.0005	mg/L	3/10/91
L-ASS2-RO	Mercury	< 0.0005	mg/L	11/17/91
L-ASS2-RO	Mercury	< 0.0005	mg/L	12/27/91
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/5/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/28/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/12/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/5/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	10/29/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/6/92
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/6/93
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/8/93
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/25/93
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/10/93
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/24/94
L-ASS2-RO	Mercury	0.00021	mg/L	4/25/94
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/5/94
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/3/95
L-ASS2-RO	Mercury	< 0.0002	mg/L	5/13/95
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/11/95
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/16/96
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/1/96
L-ASS2-RO- DUP	Mercury	< 0.0002	mg/L	4/1/96
L-ASS2-RO	Mercury	< 0.0002	mg/L	5/15/96
L-ASS2-RO	Mercury	< 0.0002	mg/L	10/29/96
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/15/97
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/15/97
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/15/97
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/8/97
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/8/97
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/12/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/12/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/31/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/31/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/30/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/30/98
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/26/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/26/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/8/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/8/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/8/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/8/99
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/11/00
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/14/00
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/8/00
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/10/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/12/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/6/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/6/01

Table 9. Summary of Analytic Results of Storm Water Runoff Samples, 1991 to 2009, LLNL. (Continued)

Sample Idenitification	Analyte	Results	Units	Date Sampled
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/12/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/12/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/20/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/20/01
L-ASS2-RO	Mercury	< 0.0002	mg/L	5/20/02
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/8/02
L-ASS2-RO	Mercury	< 0.0002	mg/L	11/8/02
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/16/02
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/16/02
L-ASS2-RO	Mercury	< 0.0002	mg/L	4/28/03
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/11/03
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/11/03
L-ASS2-RO-DUP	Mercury	< 0.0002	mg/L	12/29/03
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/29/03
L-ASS2-RO-DUP	Mercury	< 0.0002	mg/L	12/29/03
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/29/03
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/2/04
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/25/04
L-ASS2-RO	Mercury	< 0.0002	mg/L	10/26/04
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/11/05
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/16/05
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/18/06
L-ASS2-RO	Mercury	< 0.0002	mg/L	3/3/06
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/12/06
L-ASS2-RO-DUP	Mercury	< 0.0002	mg/L	2/22/07
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/22/07
L-ASS2-RO	Mercury	< 0.0002	mg/L	12/18/07
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/4/08
L-ASS2-RO	Mercury	< 0.0002	mg/L	1/22/09
L-ASS2-RO	Mercury	< 0.0002	mg/L	2/17/09
L-ASS2-RO	Mercury	< 0.0002	mg/L	10/13/09
L-ASW-RO	Mercury	< 0.0005	mg/L	2/2/91
L-ASW-RO	Mercury	< 0.0005	mg/L	2/4/91
L-ASW-RO	Mercury	< 0.0005	mg/L	3/1/91
L-ASW-RO	Mercury	< 0.0005	mg/L	3/10/91
L-ASW-RO	Mercury	< 0.0005	mg/L	12/27/91
L-ASW-RO-DUP	Mercury	< 0.0005	mg/L	12/27/91
L-ASW-RO	Mercury	< 0.0002	mg/L	1/5/92
L-ASW-RO	Mercury	< 0.0002	mg/L	1/28/92
L-ASW-RO	Mercury	< 0.0002	mg/L	2/12/92
L-ASW-RO	Mercury	< 0.0002	mg/L	3/5/92
L-ASW-RO	Mercury	< 0.0002	mg/L	10/29/92
L-ASW-RO	Mercury	< 0.0002	mg/L	12/6/92
L-ASW-RO	Mercury	< 0.0002	mg/L	1/6/93
L-ASW-RO	Mercury	< 0.0002	mg/L	2/8/93
L-ASW-RO	Mercury	< 0.0002	mg/L	3/25/93
L-ASW-RO	Mercury	< 0.0002	mg/L	11/10/93
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	1/24/94

Table 9. Summary of Analytic Results of Storm Water Runoff Samples, 1991 to 2009, LLNL. (Continued)

Sample Idenitification	Analyte	Results	Units	Date Sampled
L-ASW-RO	Mercury	< 0.0002	mg/L	1/24/94
L-ASW-RO	Mercury	0.00023	mg/L	4/25/94
L-ASW-RO-DUP	Mercury	< 0.0004	mg/L	11/5/94
L-ASW-RO	Mercury	< 0.0002	mg/L	11/5/94
L-ASW-RO	Mercury	< 0.0002	mg/L	3/2/95
L-ASW-RO	Mercury	< 0.0002	mg/L	5/13/95
L-ASW-RO	Mercury	< 0.0002	mg/L	12/11/95
L-ASW-RO	Mercury	< 0.0002	mg/L	1/16/96
L-ASW-RO	Mercury	< 0.0002	mg/L	4/1/96
L-ASW-RO	Mercury	< 0.0002	mg/L	5/15/96
L-ASW-RO	Mercury	< 0.0002	mg/L	10/29/96
L-ASW-RO	Mercury	< 0.0002	mg/L	1/15/97
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	1/15/97
L-ASW-RO	Mercury	< 0.0002	mg/L	5/23/97
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	5/23/97
L-ASW-RO	Mercury	0.0039	mg/L	11/15/97
L-ASW-RO	Mercury	< 0.0002	mg/L	11/15/97
L-ASW-RO	Mercury	< 0.0002	mg/L	12/8/97
L-ASW-RO	Mercury	< 0.0002	mg/L	12/8/97
L-ASW-RO	Mercury	< 0.0002	mg/L	2/12/98
L-ASW-RO	Mercury	< 0.0002	mg/L	2/12/98
L-ASW-RO	Mercury	< 0.0002	mg/L	3/31/98
L-ASW-RO	Mercury	< 0.0002	mg/L	3/31/98
L-ASW-RO	Mercury	< 0.0002	mg/L	11/30/98
L-ASW-RO	Mercury	< 0.0002	mg/L	11/30/98
L-ASW-RO	Mercury	< 0.0002	mg/L	1/26/99
L-ASW-RO	Mercury	< 0.0002	mg/L	1/26/99
L-ASW-RO	Mercury	< 0.0002	mg/L	2/8/99
L-ASW-RO	Mercury	< 0.0002	mg/L	2/8/99
L-ASW-RO	Mercury	< 0.0002	mg/L	4/8/99
L-ASW-RO	Mercury	< 0.0002	mg/L	4/8/99
L-ASW-RO	Mercury	< 0.0002	mg/L	11/8/99
L-ASW-RO	Mercury	< 0.0002	mg/L	1/11/00
L-ASW-RO	Mercury	< 0.0002	mg/L	2/14/00
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	2/14/00
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	3/8/00
L-ASW-RO	Mercury	< 0.0002	mg/L	3/8/00
L-ASW-RO	Mercury	< 0.0002	mg/L	1/8/01
L-ASW-RO	Mercury	< 0.0002	mg/L	1/8/01
L-ASW-RO	Mercury	< 0.0002	mg/L	2/12/01
L-ASW-RO	Mercury	< 0.0002	mg/L	3/2/01
L-ASW-RO	Mercury	< 0.0002	mg/L	3/2/01
L-ASW-RO	Mercury	< 0.0002	mg/L	4/6/01
L-ASW-RO	Mercury	< 0.0002	mg/L	4/6/01
L-ASW-RO	Mercury	< 0.0002	mg/L	11/12/01
L-ASW-RO	Mercury	< 0.0002	mg/L	11/12/01
L-ASW-RO	Mercury	< 0.0002	mg/L	12/20/01
L-ASW-RO	Mercury	< 0.0002	mg/L	12/20/01

Table 9. Summary of Analytic Results of Storm Water Runoff Samples, 1991 to 2009, LLNL. (Continued)

Sample Idenitification	Analyte	Results	Units	Date Sampled
L-ASW-RO	Mercury	< 0.0002	mg/L	5/20/02
L-ASW-RO	Mercury	0.0002	mg/L	11/8/02
L-ASW-RO	Mercury	< 0.0002	mg/L	11/8/02
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	12/16/02
L-ASW-RO	Mercury	< 0.0002	mg/L	12/16/02
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	12/16/02
L-ASW-RO	Mercury	< 0.0002	mg/L	12/16/02
L-ASW-RO	Mercury	< 0.0002	mg/L	4/28/03
L-ASW-RO	Mercury	< 0.0002	mg/L	12/11/03
L-ASW-RO	Mercury	< 0.0002	mg/L	12/11/03
L-ASW-RO	Mercury	< 0.0002	mg/L	12/29/03
L-ASW-RO	Mercury	< 0.0002	mg/L	12/29/03
L-ASW-RO	Mercury	< 0.0002	mg/L	2/2/04
L-ASW-RO	Mercury	< 0.0002	mg/L	2/25/04
L-ASW-RO	Mercury	< 0.0002	mg/L	10/26/04
L-ASW-RO	Mercury	< 0.0002	mg/L	1/11/05
L-ASW-RO	Mercury	< 0.0002	mg/L	2/16/05
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	2/16/05
L-ASW-RO	Mercury	< 0.0002	mg/L	1/18/06
L-ASW-RO	Mercury	< 0.0002	mg/L	3/3/06
L-ASW-RO	Mercury	< 0.0002	mg/L	12/12/06
L-ASW-RO	Mercury	< 0.0002	mg/L	2/22/07
L-ASW-RO	Mercury	< 0.0002	mg/L	12/18/07
L-ASW-RO-DUP	Mercury	< 0.0002	mg/L	1/4/08
L-ASW-RO	Mercury	< 0.0002	mg/L	1/4/08
L-ASW-RO	Mercury	< 0.0002	mg/L	1/22/09
L-ASW-RO	Mercury	< 0.0002	mg/L	2/17/09
L-ASW-RO	Mercury	< 0.0002	mg/L	10/13/09

Notes:

mg/L = milligrams per liter.

Table 10. Summary of Sampling and Analysis Plan, Building 212 Area, LLNL.

Sampling Activity	Sampling Strategy	Assumptions	Sampling Method	Method of Analysis	Analytical Parameters
Walk-over Survey					
Ambient Air Readings (1 inch from ground surface)	Systematic Sampling	A walk-over mercury vapor survey will be conducted in the vicinity of the Building 212 where elemental mercury in the soil was encountered and in areas where it may have been transported by wind and stormwater runoff.	Real-time Assay	Field/ Ohio Lumex mercury analyzer (RA-915+)	Field/Mercury
Soil Sampling (6 inches below ground surface (bgs)	Hot Spot Sampling	If the walk-over mercury vapor survey reading is above the daily ambient air concentration range, a soil sample will be collected from a depth of six inches. The soil sample will be analyzed on-site and if the result for mercury is above the EPA residential screening level (SL) for elemental mercury which is 5.6 milligrams per kilogram (mg/kg), additional depth-discrete sampling will be conducted. Laboratory gross alpha/gross beta and tritium will be conducted for the deepest sample in each borehole with a mercury concentration[1] over 5.6 mg/kg.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/Mercury Lab/gross alpha, gross beta and tritium
Duplicate samples (Field QC)	NA	10% of field samples analyzed in the field.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C	Field/Mercury
Scenario 1 – Surface Soil Sample					
Surface Soil Sampling (0-6 inches bgs)	Systematic Sampling	Soil samples will be collected and analyzed onsite. The results will be compared to the 5.6 mg/kg SL for elemental mercury. If the result is above the SL then additional samples will be collected in 2 ft depth intervals until the results are below the SL. Laboratory gross alpha/gross beta and tritium will be conducted for the deepest sample in each borehole with a mercury concentration[1] over 5.6 mg/kg.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/ Mercury Lab/Gross Alpha, Gross Beta and tritium
Duplicate samples (Laboratory QC)	NA	10% of field samples analyzed at contract lab.	Grab	Lab/EPA Method 7471	Lab/Mercury
Scenario 2 - Soil Samples Collected at 1 ft, 3 ft and 5 ft bgs					
Depth-discrete Soil Sampling (1 ft, 3 ft, 5 ft bgs)	Systematic Sampling	Soil samples will be collected at the specified intervals and analyzed onsite. The results will be compared to the 5.6 mg/kg SL for elemental mercury. If the result is above the SL then additional samples will be collected in 2 ft depth intervals until the results are below the SL. Laboratory gross alpha/gross beta and tritium will be conducted for the deepest sample in each borehole with a mercury concentration[1] over 5.6 mg/kg mercury.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/ Mercury Lab/Gross Alpha, Gross Beta and tritium
Duplicate samples (Laboratory QC)	NA	10% of field samples analyzed at contract lab.	Grab	Lab/EPA Method 7471	Lab/Mercury
Scenario 3 – Soil Samples Collected at 5 ft bgs					
Depth-discrete Soil Sampling (5 ft bgs)	Systematic Sampling	The soil from surface to 3 ft is backfill material placed in August 2008 after the removal action. Therefore, samples will be collected beneath the fill in native material. A soil sample will be collected at the 5 ft depth interval and analyzed onsite. The results will be compared to the 5.6 mg/kg SL for elemental mercury. If the result is above the SL then additional samples will be collected in 2 ft depth intervals until the results are below the SL. Laboratory gross alpha/gross beta and tritium will be conducted for the deepest sample in each borehole with a mercury concentration[1] over 5.6 mg/kg mercury.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/ Mercury Lab/Gross Alpha, Gross Beta and tritium
Duplicate samples (Laboratory QC)	NA	10% of field samples analyzed at contract lab.	Grab	Lab/EPA Method 7471	Mercury
Scenario 4 – Step-out Locations Soil Samples potentially Collected at 1 ft, 3 ft and 5 ft bgs					
Depth-discrete Soil Sampling (1 ft, 3 ft, 5 ft bgs)	Systematic Sampling	Soil samples will be collected at the depths where the mercury results exceeded the SL in the initial boring, potentially surface, 1 ft, 3 ft and 5 ft bgs and deeper, as necessary. The results will be compared to the 5.6 mg/kg SL for elemental mercury. If the result is above the SL then additional samples will be collected in 2 ft depth intervals until the results are below the SL. Laboratory gross alpha/gross beta and tritium will be conducted for the deepest sample in each borehole with a mercury concentration[1] over 5.6 mg/kg mercury.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/ Mercury Lab/Gross Alpha, Gross Beta and tritium
Duplicate samples (Field QC)	NA	10% of all field samples analyzed in field.	Grab	Field/ Ohio Lumex RA-915+ with soil attachment RP-91C Lab/EPA Method 900.0 and 906.0	Field/Mercury
Duplicate samples (Laboratory QC)	NA	10% of field and lab samples analyzed at lab.	Grab	Lab/EPA Method 7471	Lab/ Mercury

Notes:

[1] **Radionuclide analyses are being conducted for waste disposal profiling.**

Table 11. Inorganic Persistent and Bioaccumulative Toxic Substances and their STLC and TTLC Values[a].

Substance	TTLC[b] (mg/kg)	STLC[b] (mg/L)
Antimony and/or antimony compounds	500	15.0
Arsenic and/or arsenic compounds	500	5.0
Asbestos[c] (as percent)	1.0	—
Barium and/or barium compounds (excluding barite)[d]	10,000	100
Beryllium and/or beryllium compounds	75	0.75
Cadmium and/or cadmium compounds	100	1.0
Chromium (Vl) compounds	500	5.0
Chromium and/or chromium (III) compounds	2,500	560
Cobalt and/or cobalt compounds	8,000	80
Copper and/or copper compounds	2,500	25
Fluoride salts	18,000	180
Lead and/or lead compounds	1,000	5.0
Mercury and/or mercury compounds	20	0.2
Molybdenum and/or molybdenum compounds	3,500	350.
Nickel and/or nickel compounds	2,000	20.0
Selenium and/or selenium compounds	100	1.0
Silver and/or silver compounds	500	5.0
Thallium and/or thallium compounds	700	7.0
Vanadium and/or vanadium compounds	2,400	24
Zinc and/or zinc compounds	5,000	250

Notes:

[a] From 22 CCR 66261.24(a)(2), Table II.

[b] TTLC = total threshold limit concentration.

STLC = soluble threshold limit concentration; Waste Extraction Test (WET) analysis used.

STLC and TTLC values are calculated on the concentrations of the elements, not of the compounds.

[c] In the case of asbestos and elemental metals, applies only if they are in a friable, powdered, or finely divided state. Asbestos includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

[d] Excluding barium sulfate.

Table 12. Containers and Holding Times for Laboratory Analytical Methods, Building 212 Mercury Investigation, LLNL.

Parameter (sample quanity/container)	Analytical Method	Preservation	Holding Time
Radionuclides (2 x 16-oz P/G):			
Gross Alpha	EPA Method 900.0	Cool to 4˚C	6 months
Gross Beta	EPA Method 900.0	Cool to 4˚C	6 months
Rad Alpha Spec Analysis (10 isotopes)[1]	DOE HASL-300	Cool to 4˚C	6 months
Rad Gamma Spec Analysis (50 isotopes)[1]	DOE HASL-300	Cool to 4˚C	6 months
Tritium	EPA Method 906.0	Cool to 4˚C	6 months
Metals/Other Inorganics (1 x 8-oz G):			
Antimony	SW846 6010B	Cool to 4˚C	6 months
Arsenic	SW846 6010B	Cool to 4˚C	6 months
Barium	SW846 6010B	Cool to 4˚C	6 months
Beryllium	SW846 6010B	Cool to 4˚C	6 months
Cadmium	SW846 6010B	Cool to 4˚C	6 months
Chromium (total)	SW846 6010B	Cool to 4˚C	6 months
Cobalt	SW846 6010B	Cool to 4˚C	6 months
Copper	SW846 6010B	Cool to 4˚C	6 months
Iron	SW846 6010B	Cool to 4˚C	6 months
Lead	SW846 6010B	Cool to 4˚C	6 months
Manganese	SW846 6010B	Cool to 4˚C	6 months
Mercury	SW846 7471	Cool to 4˚C	28 days
Molybdenum	SW846 6010B	Cool to 4˚C	6 months
Nickel	SW846 6010B	Cool to 4˚C	6 months
Selenium	SW846 6010B	Cool to 4˚C	6 months
Silver	SW846 6010B	Cool to 4˚C	6 months
Thallium	SW846 6010B	Cool to 4˚C	6 months
Vandium	SW846 6010B	Cool to 4˚C	6 months
Zinc	SW846 6010B	Cool to 4˚C	6 months

Notes:

SW = Solid waste.

P = Plastic container.

G = Glass container.

oz = Ounces.

[1] See Table 6 Analytic Results for Waste Characterization from Soil Removal, September 2008, in this work plan for the complete list of analytes.

Appendix A

Mercury Detection Limit Calculations

Appendix A
Mercury Detection Limit Calculation

Calculation based on mercury transport from soil to ambient air

		Soil Parameters	
ASTM 96	r_s	1.7	Bulk Density(g/cm^3)
ASTM 96	q_{as}	0.26	Air Content (v/v)
ASTM 96	q_{ws}	0.12	Water Content (v/v)
ASTM 96	q_t	0.38	Porosity (v/v)
		Diffusivity Parameters	
EPA, 2009a	H	0.47	Henry's Constant for Mercury (unitless)
EPA, 2009a	D^{air}	0.031	Air Diffusion Coefficient (cm^2/s)
EPA, 2009a	D^{wat}	6.30E-06	Water Diffusion Coefficient (cm^2/s)
Calculated	D^{eff}_s	0.00242	Effective Diffusion Coefficient soil (cm^2/s)
EPA, 2009b	k_d	52	Soil-water partitioning coefficient (cm^3/g)
		Site Parameters	
Site Specific [1]	Ls	15.2	Depth to Subsurface Soil Source (cm)
DOE, 2010 [2]	Uair	224	Ambient mixing zone wind speed (cm/s)
DOE, 2010 [3]	W	76.2	Source width (cm)
Measurement height [4]	dair	2.54	Ambient air mixing zone height (cm)
Calculated	VFsamb	1.92E-04	Volatilization factor, soil -> outdoor (mg/m^3 -air)/(mg/kg -soil)
		Detection Requirements	
EPA, 2009a [5]	Csoil	5.6	Trigger concentration in soil (mg/kg -soil)
Calculated	Cair	0.0011	Trigger concentration in air 1 inch above ground (mg/m^3 -air)
Calculated [6]	RDL	0.0001	Required detection limit (mg/m^3 -air)
OhioLumex Co, 2000	IDL	0.000002	Manufacturer Specified Instrument Detection Limit (mg/m^3 -air)

Equations

$$D_s^{eff} = D^{air}\frac{\theta_{as}^{3.33}}{\theta_t^2} + \frac{D^{wat}}{H}\frac{\theta_{ws}^{3.33}}{\theta_t^2}$$

$$VFsamb\left[\frac{mg/m^3 - air}{mg/kg - soil}\right] = \frac{H\rho_s}{\left(\theta_{ws} + K_d\rho_s + H\theta_{as}\right)\left(1 + \frac{U_{air}\delta_{air}L_s}{D_s^{eff}W}\right)} \times 10^3 \frac{cm^3 - kg}{m^3 - g}$$

$$Cair\left(mg/m^3 - air\right) = Csoil\left(mg/kg - soil\right) \times VFsamb\left[\frac{mg/m^3 - air}{mg/kg - soil}\right]$$

Notes:

All equations from ASTM 96, Table X2.5.

[1] Site characterization data indicate source is approximately 0.5 feet below ground surface.

[2] Maximum allowable wind speed for conducting test is 5 miles per hour.

[3] Assume source width is distance from edge of 5 foot grid to center measurement location (2.5 feet).

[4] Instrument intake will be placed 1 inch above ground surface. Minimal mixing expected at 1 inch elevation.

[5] United States Environmental Protection Agency Region 9, Regional Screening Level, residential soil.

[6] 10% of trigger concentration in air.

Abbreviations:

cm	**centimeters**
cm/s	**centimeters per second**
cm^2/s	**square centimeters per second**
cm^3	**cubic centimeters**
cm^3/g	**cubic centimeters per gram**
g	**grams**
g/cm^3	**grams per cubic centimeter**
kg	**kilograms**
m^3	**cubic meters**
mg/kg -soil	**milligrams of contaminant per kilogram of soil**
mg/m^3-air	**milligrams of contaminant per cubic meter of air**
v/v	**unitless volume ratio (same volume units in numerator and denominator)**

References:

American Society for Testing and Materials (ASTM), 1996, Standard Guide for Risk Based Corrective Action, March 5, 1996. E 1739-95.

United States Environmental Protection Agency (EPA), 2009a, Regional Screening Table (Formerly PRGs), Screening Levels for Chemical Contaminants, http://www.epa.gov/region09/superfund/prg/, December 2009.

EPA, 2009b, Superfund Chemical Data Matrix, http://epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm, Website Update November 10, 2009.

United States Department of Energy, 2010, Draft Work Plan for the Delineation of Mercury in Soil at the Building 212 Facility, Lawrence Livermore National Laboratory, January.

OhioLumex Co, 2000, Portable Zeeman Mercury Analyzer, Product Flyer, http://www.ohiolumex.com/download/Ra915_flyer.pdf

Appendix B

Sample Control and Documentation

B-1. Sample Control and Documentation

B-1.1. Field Logbooks

A complete record of all samples and sampling events will be maintained by making entries into field logbook(s). Field logbooks are bound volumes with consecutively numbered pages. The Data Management Team (DMT) assigns each logbook a unique code and issues the logbooks upon request. A list of issued logbooks and their locations is maintained by the DMT. Logbooks are returned to the DMT at project completion.

ERD SOP 4.2: Sample Control and Documentation describes how entries in the sampling field logbooks reflect the sampling event as accurately as possible and includes the following information:

- Date and time of sampling.
- Sample identification (ID) code.
- Method of sample collection, including preservation techniques, size or volume, description of the matrix of the sample, and any deviations or anomalies noted.
- Requested analyses and analytical laboratory performing the analyses.
- Results of associated field measurements.
- Calibration information pertaining to field instruments used for the sampling event.
- ID of field personnel performing the work.
- ID of field equipment (model number, serial number).
- Special notes of other activities in the area which may have an impact on analytical results.

Specific field data collection forms might be used during sampling activities. Each data collection form used during sampling becomes a controlled document. The document control number is derived from the logbook code and the logbook page number that was used to document that sampling event and is recorded on specific field forms including chain-of-custody forms.

B-1.2. Chain-of-Custody (CoC) Records

As stated in Draft ERD SOP 4.2: Sample Control and Documentation, the primary objective of using CoC documents is to create an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and receipt of analytical data.

Issuance and Archival of CoC Records

- Blank CoC forms are obtained from DMT.

- Electronic COCs are produced from information in the Sampling Plan generated from the SPACT application in the Taurus Environmental Information Management System (TEIMS).
- Completed CoC records are archived by DMT.

Required Documentation

Each CoC document will be completed using waterproof ink and contain the following information:

- Document control number.
- Sample matrix. Sample matrix codes are listed on the Sampling Plan or in the TEIMS by opening the Data Team page, then using the QBF link to access the SAMPMATRIX Table.
- Name of sampler and employer.
- Requested analysis code.
- Number and type of container(s).
- Sample ID and sample date and time.
- Area from which the sample originated.
- Name of the analytical laboratory where the samples are to be sent as designated by the Sampling Plan.
- Requester name: This is the organization for which the samples are being collected.
- Additional information/instructions or remarks. The remarks section should also indicate whether field filtration and/or preservation has been performed, or if it is required upon receipt at the lab.

B-1.3. Sample Identification Labels

Detailed instructions are found in ERD SOP 4.2: Sample Control and Documentation. ID labels are to be used when tagging or labeling sample containers. The sampling personnel may fill out sample container labels after collecting samples or prior to collecting samples at each location. Waterproof ink will be used on the label.

Issuance and Archival

Sample labels may be obtained from the analytical laboratory where the samples are to be sent for analysis. The field personnel will have an adequate stock of labels on hand at all times. Labels are not archived and are destroyed with sample disposal at the laboratory.

Required Documentation

The Sample ID Label will include the following information:

- Sample ID. The sample ID can be composed of various factors such as location, sample type, etc. If a new location is to be sampled, the DMT will approve all new sample IDs.
- Project name.

- Sample date. The date when the sample was collected.
- Sample time. Time is recorded according to the 24-hour clock (e.g., 1:00 a.m. = 0100 hour, 3:00 p.m. = 1500 hours).
- Samplers' initials. The initials of personnel conducting the sampling.
- Preservation method. The nature, concentrations and volume of any preservative added to the sample should be indicated.
- Comments. Any additional information such as hold times or special turnaround times etc. should be provided in the Comments section.
- Requested analysis. The type of analysis to be performed on the sample.

The offsite CAL for the selected soil samples for elemental mercury using EPA Method 7471 will be BC laboratories, Inc.. Curtis & Tompkins, Ltd is being utilized as a QC laboratory and will receive 5% interlaboratory collocated sampled for analyses.

Sample identification methodology is described in SOP 1.1: Field Borehole Logging, Section 6.4.35, Sample Identification (ID). Included in the ID is the depth at the top of the sampling interval, which is given in feet and tenths of feet.

For soil samples collected at the Livermore Site, the sample designation distinguishes between unsaturated samples (B-#-depthU) and saturated samples (B-#-depthS). For example, a soil sample collected from borehole B-1604 at a depth of five feet in the unsaturated zone would be identified as B-1604-5.0U.

B-1.4. Records Management

ERD SOP 4.10: Records Management applies to recorded information, in any format, that is created, received or needed to document ERD work activities. The procedure describes the identification, creation, maintenance, retention, and disposition of records created or received within the ERD and will be followed throughout the course of this Work Plan.

B-2. Sample Container and Preservation

Soil samples will be placed in glass jars, or plastic bags for field analysis and in glass jars for laboratory analysis. Table 12 summarizes the container types, volume and holding times for each analyte. The samples to be collected as specified in this work plan shall be refrigerated and analyzed as soon as possible, per EPA Method 7471. Samples submitted for radiological analyses do not need to be preserved by refrigeration.

Samples requiring refrigeration at 4˚C will be protected from getting wet. Samples will be immediately placed in an ice chest containing either Blue Ice packs (in air-tight plastic bags), or bagged or loose ice cubes. A temperature blank will always be included in the ice chests so that the laboratory can check the temperature of the cooler at the time of sample receipt. If samples are not submitted to the laboratory daily, ice chests will be checked periodically, and thawed ice replaced.

Sample preservation methods will be noted as appropriate in the sampling logbook, on the sample label, and on the CoC document.

B-3. Shipping

All samples will be shipped off site according to the ERD SOP 4.4: Guide to Packaging and Shipping of Samples.

Properly identified sample containers will be placed inside Ziploc®-type storage bags, sealed, and then placed in picnic-cooler-type containers. Samples to be shipped will be packed with sufficient incombustible, absorbent cushioning material to minimize the possibility of sample container breakage. Samples that require refrigeration during shipping should be packed with a sufficient number of Blue Ice packs to keep the samples preserved. Temperature blanks will accompany all samples that require temperature preservation (4°C). They consist of a 250-ml poly container or equivalent filled with water. It will be noted in the Remarks section of the COC that a temperature blank has been included in the sample shipment. The receiving CAL will measure these blanks and record the temperature on their sample receipt log.

Appendix C

Quality Assurance/Quality Control

C-1. Quality Assurance/Quality Control

C-1.1. Quality Assurance Chain-of-Custody Practices

For each sample collected in the field, sampling personnel will follow the practices described in Appendix B, including the use of field logbooks, CoC procedures and documentation, and a standard identification label to accompany each sample at all times. The CoC form will accompany the samples through the sampling and analysis process. When samples change custody, the relinquishing and the receiving parties sign the CoC document.

C-1.2. Quality Assurance Performance Criteria

All sampling and analysis activities will be performed in accordance with the QA/quality control (QC) practices described in this work plan and related procedures. CALs selected to perform analytical tests will possess a National Environmental Laboratory Accreditation Program (NELAP) certification for the state of CA and participate in pre-award and annual DOECAP audits. NELAP requirements do not fully encompass DOE requirements. In cases, where DOE-specific requirements differ from NELAP requirements, DOE requirements will supersede and shall be met by the CALs.

C-1.3. Quality Assurance /Quality Control Practices

The QA/QC practices to be followed during the execution of this plan are summarized in this section. Adherence to these practices will produce data capable of withstanding scientific and legal scrutiny.

C-1.3.1. Field QA/QC

Field QA/QC is ensured by following uniform procedures for sample collection, handling, CoC, and shipping, and by evaluating QC samples collected in the field. QC samples shall be collected and identified in accordance with SOP 4.9: Collection of Field QC Samples. Field samples used to assess QA/QC for this work plan includes:

- Trip blanks. Trip blanks are provided by the CAL and will be submitted with each COC.
- Rinsates (equipment blanks). Equipment blanks are analyzed to determine the effectiveness of the decontamination process and will be collected prior to inserting equipment downhole in a new investigative area.
- Field Blanks. A field blank is poured at the sampling location to identify contamination that may occur during the sample collection process.
- Collocated Samples. One collocated sample per 10 samples will be randomly collected. The 10 will be divided into 5% interlaboratory and 5% intralaboratory collocated samples. When collocated samples are collected, processed, and analyzed by the same organization, they provide intra-laboratory precision information for the entire measurement system including sample acquisition, homogeneity, handling, shipping, storage, preparation and analysis. When collected, processed, and analyzed by different

organizations, these QC checks provide inter-laboratory precision information for the entire measurement system. These field QC samples are required and their purpose defined in the QAPP for the ER Projects.

C-1.3.2. Laboratory QA/QC Practices

The Quality Systems for Analytical Services (QSAS) establishes a single, integrated quality assurance (QA) program for providers of analytical laboratories supporting the U.S. DOE operations. The QSAS provides specific technical requirements and clarification for implementation of DOE requirements and is based on EPA's National Environmental Laboratory Accreditation Program (NELAP). It also incorporates EPA's Performance Approach. The QSAS is incorporated into contract vehicles or agreements and is the basis for qualification of laboratories providing services to DOE. This section summarizes laboratory practices that ensure analytical QA/QC.

C-1.3.2.1. General Laboratory Controls

In addition to instrument calibration and the analysis of QC samples, the CAL that performs the analyses must implement the following analytical controls:

- Reagents and solvents will have certified compositions.
- Reagent storage environment and duration will meet the manufacturers' guidelines.
- Laboratory equipment will be calibrated/standardized following the referenced procedures for the methods used and shall be documented.
- Volumetric measurements will be made with certified glassware.
- Data reduction computations will be independently checked.
- Qualified personnel will perform laboratory analyses using approved methods.
- QA/QC requirements and guidelines specified in the selected analytical methods will be followed.

These requirements are standard in a certified laboratory and will be verified during the laboratory inspection and validation process.

C-1.3.2.2. Laboratory QA/QC

A summary of QC sample results shall be provided for each sample and shall include the following:

- Method blank results and RLs, matrix units, batch number, date/time of analysis, instrument ID number, analyst ID, and method code.
- Surrogate or tracer yield recoveries, if applicable.
- Sample duplicate results, and relative percent difference (%RPD), if applicable.
- Matrix spike (MS), matrix spike duplicate (MSD) recoveries and %RPDs, batch number, date/time of analysis, instrument ID number, analyst ID, matrix, method code, and sample result when indicated by the method.

- Laboratory control sample (LCS) recoveries, batch number, date/time of analysis, instrument ID, analyst ID, matrix, and method code.
- QC control limits for LCS, MS/MSD, surrogate, and tracer yield recoveries, and %RPDs.
- In addition, the CAL shall provide upon request all supporting documentation used to generate reported results, including, but not limited to:
- Initial instrument calibration data.
- Continuing calibration data.
- Retention time window determinations.
- Method detection limit determinations.
- Gas chromatography/mass spectrophometry (GC/MS) tune data.
- Laboratory QC control charts.

The following minimum corrective action (provided in the Statement of Work [SOW] for each laboratory) is required to be taken by the laboratory when the QA/QC fails.

The Subcontractor shall perform at a minimum the QC analyses listed in Table 1, as well as all other required and suggested QC sample analyses specified by the EPA Methodology.

Table 1. Minimum Corrective Requirements.

QC Sample Type	QC Failure Corrective Action
Organic Analysis	
Method Blanks	Follow method specified actions if analytes are detected in the method blank greater than the calculated MDL.
Matrix Spikes	If percent recovery is outside of control limits, perform method specific corrective actions.
Matrix Spike Duplicate	If relative percent difference is outside of control limits perform, method specific corrective actions.
Laboratory Control Samples	If percent recovery is outside control limits, reanalyze sample batch for the analytes in question.
Surrogates	If percent recovery is less than the lower acceptance limit, reanalyze sample.
Trip Blanks, Field Blanks	If analytes detected in associated samples, analyze all associated trip and field blanks.
Inorganic Analysis	
Method Blanks	Analyte detections in the method blank and instrument blank are unacceptable. If analytes are detected in the blank and in the samples, re-digest/reanalyze samples or, upon approval from the LLNL project managers, implement method specified actions.
Matrix Spikes	If percent recovery is less than 30, perform a post-digestion spike LLNL samples to check for matrix interferences.
Matrix Spike Duplicate	If relative percent difference is outside of control limits perform method specific corrective actions.
Laboratory Control Samples	If percent recovery is outside control limits, reanalyze sample batch.

Radiological Analysis	
Method Blanks	Follow method specified corrective actions if analytes are detected in the method blank above sample Minimum Detection Activity (MDA).
Matrix Spikes	If percent recovery is outside of control limits perform method specific corrective actions.
Sample Duplicate	If relative percent difference and/or relative error ratio is outside of control limits, perform method specific corrective actions.
Laboratory Control Samples	If percent recovery is outside control limits, reanalyze sample batch.
Tracer Yields	If percent recovery is less than the lower acceptance limit, reanalyze sample.

When field QA/QC fails, as determined during ERD's data validation process, the course of action taken is decided at that time and may include, requesting a re-analysis, re-sampling, or appropriately qualifying the data in accordance with SOP 4.6: Validation and Verification of Radiological and Nonradiological Data Generated by Analytical Laboratories.

C-1.4. Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC)

Analytical data will be evaluated according to the PARCC parameters to have a level of assurance of the quality of the measurement data. These parameters are necessary when considering the usefulness of a set of data for interpretation. The definitions provided are established in the approved QAPP for the ER Projects.

C-1.4.1. Precision

Precision is determined by the degree of agreement between duplicate analyses of the same parameter in a given sample. It is an indicator of how well a laboratory can reproduce its work under a given set of conditions. Precision is expressed as %RPD and is determined by the laboratory by the analysis of MSDs, sample duplicates, or LCS duplicates. The %RPD is compared to set control limits to determine acceptability. ERD also assess precision by the analysis of intralaboratory and interlaboratory collocated samples.

Field audits, and checklists will be performed on a routine basis. These audits will document the use (or nonuse) of uniform sampling methods and of handling and shipping procedures.

C-1.4.2. Accuracy

The analytical laboratories analyze QC samples to assess precision and accuracy. Accuracy is defined by the degree of agreement between measured value and true or known value. It is a measure of the bias in the measurement system. The laboratories assess accuracy, expressed as percent recover (%RCV), by the analysis of MSs and LCSs. The %RCV is compared to set control limits to determine acceptability.

C-1.4.3. Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition. Representativeness is a qualitative term that determines whether *in situ* and other measurements are made and physical samples collected in such a manner that

the resulting data appropriately reflect the media and phenomenon measured or studied. ERD uses sampling techniques and EPA prescribed sample preservation to ensure that the samples are representative of the media of interest.

C-1.4.4. Comparability

Comparability is the measure of the confidence with which one data set or method can be compared to another. Standard techniques are used to collect and analyze representative samples to ensure comparable results.

C-1.4.5. Completeness

The ERD Annual QA Report summarizes completeness by determining the completeness of the data set in terms of the number of valid results obtained for the number of analyses planned. The Livermore and Site 300 ERPs completeness objective is 90%.

C-1.5. Data Review, Validation and Verification

Data will be reviewed by the QC Chemist upon receipt from the analytical laboratory. During this review, the chemist will verify and validate the data in accordance with the LLNL QAPP and ERD SOP 4.6 Validation and Verification of Radiological and Nonradiological Data Generated by Analytical Laboratories.

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